AVIATION

AND

AERONAUTICAL ENGINEERING

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View from Flying Boat of New York Naval Militia Aviation Camp at Bay Shore, N. Y.

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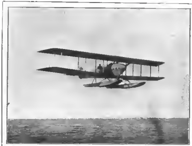

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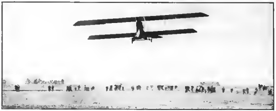

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AUGUST 1, 1916 VOL. 1. NO. 1

AVIATION AND AERONAUTICAL ENGINEERING

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Some of New York State's Military and Naval Fliers

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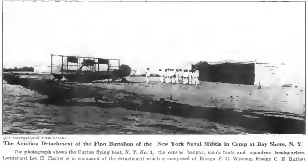

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The Aviation Detachment of the First Battalion of the New York Naval Militia in Camp at Bay Shore, N. Y.

The photograph shows the Curtiss flying boat, *N. Y. No. 1*, the canvas hangar, men's tents and squadron headquarters. Lieutenant Lee H. Harris is in command of the detachment which is composed of Ensign F. C. Wyzong, Ensign C. E. Ruttan, Eustice L. Adams, Harold R. Eustis, Robert J. Kahl, Frederick E. King, Frank W. La Vista, Charles J. McEnroe, Walter L. Roder and Howard W. Ross.

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AVIATION AND AERONAUTICAL ENGINEERING

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Vol. 1 August 1, 1916 No. 1

THE future of the aeroplane will depend largely on the use that is made of the technical information that is being gathered in all parts of the world. As this data is made available to the constructor and engine maker, they will find its utilization more and more imperative for the scientific improvement in design and construction from the standpoint of safety and efficiency. Aeronautics has passed through the period of rule of thumb designing and empirical experimentation. It is now a recognized science subdivided into many branches, and those who are working in aeronautical engineering can rightly claim that it has reached the dignity of a profession.

The pioneer work of the Wrights was not done wholly on the field. Their most important experimental activities were carried on by innumerable tests in their primitive wind tunnel and by mathematical calculations still in existence. The confidence with which they undertook their early work and the freedom from accidents were due mainly to the technical information they had gathered from every source available and the preliminary tests they made in their crude laboratory.

Until the last few years aviation was not regarded seriously by the scientific world. It was considered only as a field of operation for the daring pilot and the enterprising sportsman. But now many of the most distinguished scientists in all countries are giving aeronautics close and careful study. From the work of these men aeronautics will derive the information upon which progress, such as has never even been thought possible, will be achieved.

The United States, while deplorably backward in the expansion of aviation from the governmental standpoint, has been quietly coming to the front in its research work. The technical schools have established courses in aeronautics and highly trained specialists have been investigating various problems. Abroad numerous laboratories have produced an enormous volume of material. Much of this invaluable data has not been published, and such as has been given out has been uncorrelated and can be found only in widely scattered publications.

AVIATION AND AERONAUTICAL ENGINEERING intends to assemble this vast amount of material and make it useful to the constructor, the engine maker, the aviator and the sportsman. It will follow construction both abroad and in the United States and present the latest developments in accurate, scientific and unbiased form. It is hoped that by undertaking this task a great stimulus will be given to the whole aeronautical profession. By recording the work of American aeronautical engineering, the world will soon be made aware that the birthplace of the aeroplane is still maintaining its leadership in aeronautics. By presenting in usable form the work done abroad by the leaders in this field, AVIATION will perform a service of incalculable value to American industry.

It is hoped that by undertaking this great task a stimulus will be given to the whole aeronautical profession, the members of which will find in the new publication a continuous source of reliable information as well as a medium worthy of receiving and transmitting to the aeronautical world the results of their valuable experiments, researches, constructional developments and matured views on the many controversial aspects of this great branch of engineering.

The Appropriations for Aeronautics

The Congressional appropriations for aeronautics have shown that at last the importance of this arm of the military and naval services is being taken seriously. The public, awakened as it is by the daily reports of air exploits, is in a mood to support any action which Washington takes in the direction of American supremacy in the air.

The early expenditures for battleships, dry docks and other naval equipment seemed huge to the average citizen, but by making comparisons with foreign costs this impression soon disappeared. In the same way, the amounts necessary for the establishment of aviation on a proper scale in the Army, Navy, National Guard, Naval Militia and Coast Patrol will have to be compared with European expenditures to show how imperative it is to appropriate millions on millions of dollars for this increasingly important service.

It is unfortunate that the war has closed sources of information which would help everyone to see the grave danger of unprotected skies. Such news as comes through the censors is mainly spectacular. The vast expansion of the air services in the warring countries is not allowed to become known. The huge sums expended for laboratories, training stations and flying fields, repair shops and training personnel will only become known after the war. Then will come the awakening. Congress cannot be urged too strongly to listen to the advice of experts both in and out of the government service and be guided by their conclusions.

M EIFFEL IN HIS LATEST AERODYNAMICAL LABORATORY

Course in Aerodynamics and Aeroplane Design

By A. Klemin, A.C.G.I., B.Sc., S.M.

Instructor in Aeronautics, Massachusetts Institute of Technology, Member of the Aeronautical Society of Great Britain and Ireland,

and

T. H. Huff, S.B.

Instructor in Aeronautics, Massachusetts Institute of Technology

INTRODUCTION

THE COURSE WILL BE SUBDIVIDED INTO TWO PARTS
PART I. AERODYNAMICAL THEORY AND DATA.
PART II. AEROPLANE DESIGN

In PART I it is proposed to deal briefly with the fundamental ideas and theories of aerodynamics in a simple yet comprehensive manner

It is important for the aeronautical engineer and for every student of aerodynamics to have at his disposal exact definitions of such terms as lift, drag or resistance, center of pressure, wing cord, angle of incidence, and other well known expressions

Although the exact nature of viscosity, skin friction, eddying or density resistance, stream line flow, turbulent flow, the sustaining action of cambered wing surfaces, and the principles of comparison for forces on bodies of varying dimensions still present many difficulties, it is hoped to give a simple and above all practical summary of these points The more difficult theoretical demonstrations will be reserved for special articles.

The authors propose also to give a brief description of the chief aerodynamical laboratories and of experimental methods there employed Without a knowledge of such methods, appreciation and application of the laboratory data available is certainly not easy

Considering the comparatively recent growth of aerodynamics, the amount of material now available is extraordinary It is unfortunately scattered through a variety of publications, English, French, German, Russian and Italian, presented in varying ways and in varying systems of units Nor is all of it entirely worthy of credence

In this course it has been attempted to reduce this material particularly that of English and French origin, to one system of presentation with forces measured in pounds, areas in square feet and velocities in miles per hour or feet per second, so as to be more readily applicable in American design, to include all the material which is trustworthy and of immediate and pressing utility to the designer, in carefully classified form

The Economic Laws of Flight will be fully dealt with, in horizontal and ascensional flight The consideration of the performance curves of a machine will be particularly useful to those engineers and students to whom the subject is comparatively new

Throughout, illustrative problems will be worked out on important points, especially to facilitate comparison between wing sections

PART 2 will include a discussion of available aeronautical materials, timber, steel, alloys, rubber, etc—with trustworthy values for stresses; a variety of diagrams and scale drawings representative of modern design, and a classification of the most important modern machines with their main data.

At this stage of the art, it is impossible to say that any method in design is standard, but a systematic procedure of design will be fully developed.

Particular stress is laid on the evaluation of factors of safety The dynamic factor of safety, the material factor of safety, the worst loading possible in the air, the worst possible shock on landing, nothing offers so many possibilities of confusion and untrustworthiness, and nothing is in more need of definite and accurate statement

Complete strength calculations will be presented for fuselage, chassis, wing girders, and controlling surfaces, and the design of a standard machine will be carried through, with consideration of motor and propeller problems, weight distribution and balancing

Finally two sections will be devoted to a consideration of dynamical stability, longitudinal and lateral. These problems have been ably treated by a number of distinguished men: Bryan, Bairstow, Reisner Hunsaker and Wilson, but merit a more simplified and more readily applied treatment

THROUGHOUT THE COURSE, THE MOST ELEMENTARY MATHEMATICS ARE EMPLOYED, AND NOTHING BEYOND A KNOWLEDGE OF THE FIRST MECHANICAL PRINCIPLES IS PRESUPPOSED.

It is hoped, therefore, that the course will be easily understood by any engineer or student approaching the serious study of the aeroplane for the first time. At the same time it is felt that much will be of service even to the expert aeronautical engineer

The authors feel that they are greatly indebted to Lieutenant Jerome C. Hunsaker, whose research and classification work at the Massachusetts Institute of Technology has largely rendered possible a systematic presentation of this great subject

PART I.—SECTION 1

Modern Aeronautical Laboratories

Early Experimental Aerodynamics

Aeronautics as a whole and aviation, the science of the heavier than air machine, has from its earliest conception, been an experimental art. When Professor Langley in 1887 started his experiments on an extended scale for determining the possibility of, and the conditions for, transporting in the air a body whose specific gravity is greater than that of air, he had before him papers by such scientists as Gay-Lussac and Navier, proving conclusively that mechanical flight was impossible.

Langley was not easily discouraged and by a carefully conducted series of experiments carried on under very adverse conditions, he was able to build a machine which though unsuccessful in its flight in his day, due to faulty mechanism

in the launching device, has since been flown under its own power by Glenn Curtiss in 1914, at Hammondsport, N Y—possibly with some alterations.

At the time the Wrights took up the subject in 1896, there were but few aerodynamical works of interest or value in existence. They were dependent upon the meager experiments and tables of Lilienthal and Duchemin and the work of Langley which seemed to verify Duchemin's formula. After spending two years experimenting upon these figures of Lilienthal and Duchemin, the Wrights came to the conclusion that the tables were so much in error as to be of no practical value in aeroplane design.

In 1901 the Wrights designed and built a small "Wind-Tunnel" in which they could carry on systematic investigations on the pressure produced by various surfaces when presented to the air at different angles. The instruments used in measuring these forces were designed with the intention of correcting the errors which had rendered so untrustworthy the results of their predecessors.

During the winter of 1901-1902 their investigations included some hundred different surfaces of which about half have been tabulated and the results used in their subsequent work. Experiments were made on the effect of varying aspect ratio curvature, camber, and the variation of the position of the maximum ordinate of the wing section from the leading edge. Thick and thin surfaces were tested to determine the effect of thickness. The effect of superposing the surfaces, as well as placing one behind the other, were measured and what is of even greater interest, the first measurements of center of pressure motion on curved surfaces at varying angles were tabulated by them. As a direct result of their laboratory experiments and the development of a system of control, worked out in their earlier gliding flights, they were able to build the first power driven aeroplane.

To demonstrate that the United States deserved a right to leadership in aviation in the earlier years, one need but mention other names, such as those of Octave Chanute and Dr Zahm. The latter, through the efforts of Hugo Mattlullath, was provided with an aerodynamical laboratory which was in its day the most perfect of its kind, although the experiments extended over a few years only, the results of Dr Zahm's labors were exceedingly valuable.

General Requirements in Aeroplane Design

As is the case in ship building, a suitable machine for every purpose cannot be developed and there must be a special type with specific qualities in slow speed, high speed, weight, armament and defense. Some of these factors are directly opposed to others. For example, the ideal machine for the regulation of artillery fire, would be able to remain immovable or circle about very slowly above one point. The "chaser" or machine used to rid the air of the enemy's planes should be the fastest possible. With the comparatively narrow range of speed possible in an aeroplane one can see the uselessness of an attempt to combine these two types in one machine. On the other hand from the productive side, it is impracticable to increase the number of types indefinitely, for this would call for an enormous outlay in machinery and increase in personnel. A compromise has therefore been made, with the selection of some four master types of aeroplanes which may be classed according to their military uses.

1. The Strategic Scout. A slow endurance machine for use on long raids into the enemy's country, for mapping and photographic work.

2. The High Speed Scout. For tactical reconnaissance and use over the lines, and capable of out-climbing and out-flying the enemy.

3. Fighting or Battleplane. Armed and armored, for driving off the enemy's scouts and protecting the fourth class.

4. Bomb Droppers or Weight Carriers. For use in destroying small bridges, railways, etc., depending for their protection upon the battleplane.

In order to design and build machines to meet such qualifications the designer must give up the old haphazard methods of building first, and then determining the performance. He must go about the design in a thorough and scientific manner in order to hope to come within reasonable limits of his specification.

The most important items in the performance of present-day machines are—their weight, their rate of climb, high and low speeds, angle of glide, propeller efficiency, and endurance at economical speed for various loadings. These depend on a careful manipulation of aerodynamical data, including the lift and resistance of the main planes and control surfaces, the resistance of struts, wires, wheels, radiators and appendages, the distribution of loads on surfaces, and different combinations of surfaces. On the effects of the various supporting, control and fin surfaces, and on the summation of all aerodynamical forces depend not only the performance, but the controllability, factor of safety, and stability of the aeroplane. To produce a desired type the designer must bear in mind every factor.

The desired type can be obtained by the "cut and try" process on the full size machine. This experimental flying is, however, a dangerous and costly method that has led to many an unfortunate accident.

Difficulties of Full Scale Experiments

The real worth of full scale experiments depends on the delicacy and precision of the recording instruments, the expertness of the pilot and the interpreter of the recorded data. The chief objections, other than that of danger to the pilot, are the great variations in atmospheric conditions and therefore the unavoidable delays in tests, the inability to repeat the trials under exactly the same conditions, the necessarily short time allowable for observation and the unavoidable introductions of many variables, when but a slight change is made in one part of the design. It is this inability to discriminate among the possible causes of behavior of the machine that may lead to a maze of conflicting results.

There is a place, nevertheless, and a very important one for full sized experimental flying—that the machine may be tuned up and minor adjustments made for ease of control and steadiness under actual flying conditions. Such work, however, should not be undertaken until the safety of the pilot is reasonably assured.

Towing Methods

The most natural and logical thing to do with model aeroplanes would be to tow them through still air and record the forces and moments to which they are subjected. This is not so simple an arrangement as in marine work. The aeroplane is free to move along the three axes in space and around any of the same, which introduces complications in the recording mechanism that are most difficult to overcome. Very much higher speeds are required in aeronautical work and this increases the length of track for testing prohibitively or decreases the time of experimental observation to such an extent as to spoil the precision of the results.

The principal objection to towed model flight is the inability to obtain *still* air, as even in a closed room eddies are con-

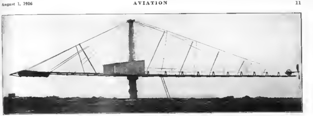

Fig. 1. Whirling Arm Used by Messrs. Vickers in Testing Propellers

stantly present, which are impossible of measurement; this may be observed by making apparently calm air visible by the introduction of smoke. Radiation of heat from the walls is apt to cause such eddy making to a very marked degree.

In a measure the difficulties of rectilinear motion are overcome by replacing it by rotation about a fixed axis, but here the radius must be relatively large and the building necessarily of similar great dimensions. The rotation is not wholly comparable with translation since along the transverse axes of the body, under test, the different parts have not the same relative velocity and some compromise is necessary due to this difference in radial length. Centrifugal force is present which must be overcome by the measuring instrument, as well as the disturbance set up in the air by so large an object as the whirling-arm passing the same point a number of times.

The whirling arm used by Messrs. Vickers, Ltd., of England, in their experimental work is illustrated in Fig. 1.

The Wind Tunnel Methods

If we are willing to accept the doctrine of relative motion, then the resultant force on a solid with a uniform motion through still air, is the same as that for an immovable solid upon which a constant current of air impinges. A "Wind Tunnel" test, where a steady current of air impinges on a model at rest, should therefore give the same results as a towing test. Differences would be due to experimental errors and not to a difference in principle.

In the towing method, the influence of the mounting stage and unsteadiness of the air introduce errors. In the wind tunnel, there may be slightly non-uniform flow, disturbances due to the sides of the tunnel, etc. Wind tunnel work, however, has proved far superior to the towing method, which it has almost entirely replaced and it has now been developed to a high degree of precision and usefulness.

From wind tunnel tests, the engineer may obtain data for the "balancing" up of an aeroplane—the adjustment of the center of gravity with reference to the air forces, the loading on his wing and control surfaces; the resistance of the body and appendages, and other useful information. It will be scarcely disputed that such tests are of immediate commercial value to the practical designer.

Aeronautical Laboratories of the Wind Tunnel Type

The Institut Aérotechnique de l'Université de Paris, under the directorship of M. Maurain and M. Toussaint, situated at St. Cyr some ten miles out of Paris, is devoted, for the most part, to experiments on full size surfaces and aeroplanes. Covering some eighteen acres of land, a splendid opportunity is offered for ample buildings, as well as the seven-eighths of a mile railway track used for experimental work.

The main building with a large central hall is surrounded on three sides with work shops, laboratories and a power station. Within the hall is installed the experimental apparatus directly connected with aviation. Here there are several wind tunnels of different dimensions and wind speed, arranged for the testing of scale models and appendages, apparatus similar to Colonel Renard's for the investigation of stability and proper propeller testing apparatus. A motor testing plant for endurance and economy of aeronautical motors, instruments for measuring the propeller torque for various rotational speeds at a fixed point and the testing of propellers at rupturing speeds are also included.

In the chemical laboratory investigations on balloon fabrics and gases are undertaken with special reference to their manufacture and purification. The physical laboratories are de-

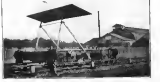

Fig. 2. First Platform Equipped for Trial at Aerotechnic Institute of Saint-Cyr

voted to the production of instruments for aeronautical purposes, both experimental and applied. Work shops are at one end and an individual power station supplies energy and light to the Institute and experimental departments.

In a separate building, covering a quarter of an acre, is

housed a "whirling-arm" some 50 feet in radius, used principally for the calibration of instruments. It is, however, not as popular as the track and wind tunnel experimental apparatus. The out-door track proper is of standard gage, 7/8 of a mile long, level for the part over which experimental data is recorded, but rising slightly for some distance at either end to facilitate the starting and stopping of the five-ton electric car, upon which the surface, full size aeroplane or propeller is mounted and carried.

Four cars, each rigged for one type of experiment, are con-

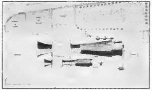

FIG. 3 PLAN OF EIFFEL'S AERODYNAMICAL LABORATORY

sidered necessary. Number one measures the horizontal and vertical components of the resultant air force, as well as the center of pressure for various angles of incidence of the surface to the wind; two and three are for large and small propellers in connection with dirigible and aeroplane work; and number four is especially equipped for the measurement of the resistance of appendages. The carriages are equipped with appropriate measuring instruments of the recording type, readings being recorded simultaneously as the car moves over the track. The velocity of the air is recorded by means of a calibrated venturi tube anemometer.

The testing apparatus is of such size that a full scale aeroplane can be mounted and subjected to test for lift and resistance and static longitudinal stability. In order to accommodate such large forces as are encountered in full scale work the instruments are of considerable size. This has the disadvantage of destroying much of the delicacy of the measurement. The results obtained are said to be in error by about five per cent in lift and about ten or fifteen per cent in resistance. The real value of experimental work of this nature and its comparison with results obtained from model tests is as yet not fully determined.

Eiffel in his laboratory at Auteuil, in an investigation to ascertain the aerodynamical effect produced by the car, situated as it was directly beneath the surface under test, reports that when correction is made for the presence of the carriage agreement with wind tunnel results is fairly obtained. He also notes that modification is being made at St. Cyr in the position of the surface as mounted on the car in order to reduce the interference as much as possible. A similar comparative test made at the National Physical Laboratory, England, on wind tunnel models shows good agreement with the lift coefficients, but the resistance coefficient in the full size experiment is still unsatisfactory.

The Laboratoire Aérodynamique Eiffel, supported by the personal means of, and directed by G. Eiffel is of the most elaborate in design. Devoted entirely to wind tunnel experiments, it is completely housed in a beautiful white stone building, fronted by a formal garden. The building proper, two stories in height, is 100 by 40 feet.

As may be seen by the accompanying photographs, the laboratory room is rectangular in shape, with a large and small wind tunnel side by side, occupying the central space and suspended mid-way from floor to ceiling. The position of the tunnels permits the free circulation of the air in the room. The wind tunnels are of similar character, one being of smaller working diameter than the other. They each consist of a bell shaped collector, a large laterally *air tight* experimental chamber, used for both the large and small tunnel, and independent expanding trunks leading from the experimental chamber to the individual suction blowers. The air is drawn from the large surrounding room or hangar into the bell collector, through a honey-comb baffle to straighten the flow, then across the experimental chamber into the expanding trunk where it passes through the suction blower and is discharged at low velocity, back into the room.

M. Eiffel's characteristic variant is his hermetic experimental chamber. When first interested in experimental aeronautics, he experienced difficulty, due to interference of flow

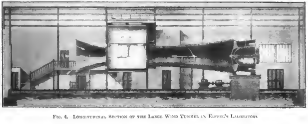

FIG. 4. LONGITUDINAL SECTION OF THE LARGE WIND TUNNEL IN EIFFEL'S LABORATORY

around his models caused by the walls of the closed tunnel. In order to avoid a tunnel of excess size and still not reduce his model dimensions, the walls were removed for some distance and replaced by an air-tight chamber enclosing the stream of air. The pressure in the hermetic room is necessarily that of the air stream it contains, so that a cylinder of air traverses the chamber in parallel stream lines and without showing any appreciable eddy. If a fine silk thread is held in the working stream, a slight play up and down or to the right and left may be noted, showing some variation is present. The velocity of the stream is measured by an alcohol manometer, registering the difference in pressure in the experimental chamber and the laboratory room outside. This is one method of velocity determination and will be explained in detail later. The manometer when left to itself shows a slow variation in velocity with time of some four per cent.

The general dimensions of the installation at Auteuil are as follows: The large channel has a bell collector with end diameters of 4 and 2 meters, 13.1 and 6.6 feet, with a length of 3.3 meters, 10.8 feet, and an expanding trunk 9 meters, 29.5 feet, long with end diameters equal to the collector. The expanding trunk connects with a suction blower, having a sectional area of 9 square meters, 97 square feet. The small tunnel comprises a bell collector, ends 2 meters and 1 meter in diameter, 1.65 meters in length and an expanding trunk 6 meters long, connected to a Sirocco suction blower.

The above dimensions permit in the larger a uniform stream of air 2 meters, 6.6 feet, in diameter to be drawn through the experimental chamber at a speed varying between 2 and 32 meters per second, or 6 and 105 feet per second; this is accomplished by a 50 horse power electric motor driving a 50 per cent efficient blower. In the small tunnel of 1 meter diameter air flow, a maximum velocity of 40 meters, 131 feet, per second, is obtained by a 50 horse power electric motor driving the Sirocco blower.

The experimental chamber is a rectangular room free from obstructions 10 meters, 33 feet, in length, 4 meters, 13.1 feet in width and 5 meters, 16.4 feet, in height. A rail supporting a sliding floor carries the observer and weighing mechanism above and clear of the air stream. A second observer on the floor is required to regulate the wind and adjust the model during a test. The two tunnels are of course so arranged that the one not in use may be blocked off with air tight wall plates so preserving the low pressure in the experimental chamber. In order to avoid the possible physical discomfiture often accompanying sudden changes in pressure, an air-lock is provided for passage into or out of the experimental chamber.

The models are mounted upon especially designed standards or measuring instruments, such as a large and small aerodynamical balance—devices for measuring the lateral forces, pressure distribution and a very excellent apparatus for testing small propellers. All the apparatus is mounted in the most convenient manner and may be used for either the large or small channel as desired. The accuracy of the results obtained, while possibly not sufficient for exact physical research, are ample, from the practical stand point.

The Deutsche Versuchsanstalt für Luftfahrt zu Adlershof, superintended by Prof. Dr. Bendemann, is of the same order as the experimental grounds at St. Cyr, but on a much less elaborate scale. The work is principally on full scale aeroplanes and block tests on aeronautic motors. One building is devoted to full scale testing, another to construction and repairs and five smaller ones to the housing of motor testing apparatus. The main building has a central tower some 100 feet in height from which wind observations may be made and other atmospheric conditions recorded. Cables from the top of this tower are used to support full size aeroplanes in the determination of their moments of inertia. A track outside of the building is used, as at St. Cyr, for the testing of full size aeroplanes or surfaces. In this instance a locomotive used to push the mounting stage is substituted for the St. Cyr electric driven car, a rather doubtful adjunct.

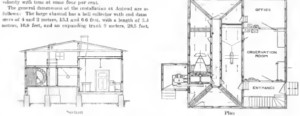

FIG. 5 THE GOTTINGEN AERODYNAMICAL LABORATORIES

The Göttingen Aerodynamical Laboratory, under the supervision of Professor Prandtl, has little of the ornate as compared to the Eiffel Institution, housed as it is in a plain one story brick building, 30 by 40 feet in size. The building, as may be seen from the drawing, is about equally divided between wind tunnel and office space. Glass doors in the side next the observation room permit of access to the experimental section of the tunnel, while trap doors open here and there to allow entrance into other sections for the adjustment of the honey-combs, baffles, etc.

Unlike the Eiffel tunnel, the air follows a closed circuit necessitating the turning of four corners. The 2 meter diameter blower, driven by a 30 horse power electric motor, forces a steady current of air through the 2 meter, 6.6 foot, square wooden tunnel. At a short distance down stream the air passes through the first honeycomb, 400 large square metal cells, similar to the pigeon holes used for post office boxes. These cells are so constructed with two-ply metal walls that the quantity of air passing through any one may be regulated

by partly bending out one thickness wall to obstruct the passage. The cells, in many instances, have been so restricted to regulate the air flow that it might be as uniform as possible. Vanes, similar to those of a turbine, are utilized at the four corners to turn the current through a 90 degree angle, without producing excess eddy-motion. After the second turn, just before the air enters the experimental part of the tunnel, it passes through the second honeycomb, much finer than the first. This last honeycomb is constituted of about 9,000 cells from which the air, after passing a wire mesh to remove any foreign matter, issues with a maximum velocity of 10 meters or 32.8 feet per second, to act upon the model suspended some distance down stream.

A great deal of the work in the Gottingen Laboratory has

individual adjustable dampers used as a control upon the quantity of air passing and so producing uniform flow to within about 2 per cent. The balance and motor control are mounted on a platform upon the roof of the tunnel. The model is supported in a horizontal position in the wind on a balance similar to that of Eiffel's and sensitive to at least 1/1000th of a pound. Models up to 36-inch span are permitted without noticeable interference from the walls or choking of the air flow.

The velocity measurements are unique in that in place of a single pitot and pressure tube, placed in the vicinity of the model, a series of twelve tubes equally spaced, directly on the discharge side of the blower record on an intergrating manometer the velocity of the stream. The velocity of the

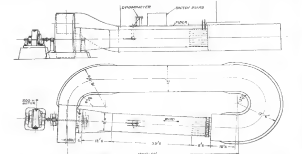

FIG. 6 ELEVATION AND PLAN OF THE WIND TUNNEL OF THE UNITED STATES NAVY DEPARTMENT

been devoted to the resistance of airship hulls, etc., for which work a special suspension method of mooring wires, bell cranks and weights, has been adopted with great success. A differential pressure gage, sensitive to pressure changes of one millionth of an atmosphere is used in the determination of velocity. Many interesting experiments on the distribution of pressure have been conducted upon small propellers, constructed by electroplating with copper, wax models. A more detailed description of the suspension device and differential gage will follow.

The Wind-tunnel of the United States Navy Department, under Naval Constructor Holden C. Richardson, at the Washington Navy Yard, Washington, D. C. The tunnel is similar to the German Gottingen Laboratory in that the air is confined in a closed circuit, in this case eight feet square at the test section. The cross sectional dimensions vary as may be seen in the accompanying print, in order to compensate for the curves taken by the stream. Only one set of honeycomb baffles is employed, these being placed just at the entrance of the experimental chamber and 20 feet up stream. These 64 cells, each one foot square and eight feet long, are equipped with

stream from the blower has a direct relation to the velocity of the wind in the experimental chamber, against which it has been calibrated for all speeds. The pitot tubes used have been themselves checked with the standard tubes of the National Physical Laboratory of England and the Aerodynamical Laboratories of the Massachusetts Institute of Technology.

Power for driving the suction blower is supplied by a 500 horse power 250 volt direct current electric motor, operated on the Ward-Leonard system. A velocity of 75 miles an hour may be obtainable, but due to the heating of the air by friction and other difficulties in maintaining regular flow this high speed is seldom utilized. Generally tests are made at a speed of about 40 miles an hour.

The National Physical Laboratory at Teddington and the Royal Aircraft Factory at Farnborough, England, constitute the most complete aeronautical experimental combination in the world. The aeronautical portion of the National Physical Laboratory is devoted to experimental investigations of the British Advisory Committee for Aeronautics. This committee, with Dr. R. T. Glazebrook as chairman, and such able coworkers as Dr. Stanton and Mr. L. Bairstow, initiates

the investigations at the N. P. L. and oversees the general work in aeronautics throughout the Kingdom.

The Royal Aircraft Factory, superintended by Mervyn O'Gorman, works in close co-operation with the N. P. L. It has facilities for model experiments, but is more concerned with tests on full size aeroplanes and the application of the investigations of the National Physical Laboratory. There is necessarily some overlapping in the work carried on at the two institutions, but no interference.

The Royal Aircraft Factory before the war, was the largest factory then in existence, devoted to the manufacture of aeroplanes. All the experiments are carried on in the large flying field in connection with the factory. Machines equipped with intricate recording instruments are flown under their own power and such important information as power utilized, angles of pitch, roll and yaw, speed through the air, altitude and control movements are simultaneously recorded. This, in

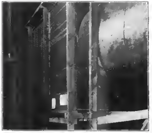

FIG. 7. EXTERIOR OF THE WIND TUNNEL AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, SHOWING CELLS THROUGH WHICH AIR IS SUCKED IN FROM THE ROOM

a true sense, is full scale experimental work and the results have been to disclose defects and encourage the improvement and safety of the machines. By the careful application of the model experimental work of the N. P. L. an inherently stable biplane with a speed range of 40 to 80 miles an hour had been produced by the R. A. F. before the war. Improved machines of this type have been of greatest value to the Royal Flying Corps.

The National Physical Laboratory has turned over ample space for the exclusive use of the Aeronautic Committee, comprising a large and small wind tunnel house, a whirling table house and ample space for any independent investigations. The small and large wind tunnels are of similar character, one 4 and the other 7 feet square in cross-section. Each is mounted in a separate building, the smaller being included in the engineering laboratory building. For details of the small tunnel, reference is made to the description of its duplicate in the Massachusetts Institute of Technology Laboratory. The new 7 foot tunnel only differs from the 4 foot in its dimensions and power. It is 80 feet in length with an air flow of sixty feet a

second produced by a low pitched four bladed propeller driven by a 30 horse power electric motor.

A great amount of time was spent in experimenting with this form of tunnel before the committee was satisfied with the results. They have the deep satisfaction of knowing that the artificial wind produced by it, is the most uniform in the world and adaptable to the most scientific research. The cur-

FIG. 8 (A) PROPELLER AND (B) AERODYNAMIC BALANCE IN USE AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

rent is uniform in velocity, both in time and space, to within one-half per cent. The velocity measurements and aerodynamical balance will be described in detail later. It suffices here to say that they are as carefully worked out and results obtained as gratifying as the wind tunnel itself. The work of the committee has been extremely broad and the results are of untold value to aeronautics. The whirling-arm and small water channel, the former used in the calibration of velocity

FIG. 9 ENTRANCE NOZZLE SHOWING HONEYCOMB

instruments, the latter in the study of stream line flow, are both examples of high engineering skill.

The Wind-tunnel of the Massachusetts Institute of Technology was built after a careful study of European Laboratories on plans furnished through the courtesy of the National

Physical Laboratory Maintained in connection with graduate course in aeronautics at the Institute, with the helpful co-operation of Professor Peabody of the Naval Architectural Department, and under the former directorship of Lieutenant J. C. Hunsaker, U. S. N., the work has been of the most commendable character.

The tunnel is housed in a temporary building on the new Technology site in Cambridge, with offices in the main Institute Building. Enclosed in a 20x25x60 foot shed, the tunnel is suspended in the center of the room, six feet from the floor,

FIG. 10 INTERIOR OF DIFFUSER LOOKING FROM PROPELLER

so that ample space is provided for the free circulation of air. The illustrations indicate the general form of the tunnel which has an overall length of about 56 feet and a working section 4 feet square. The air which is drawn from the room around the cowled entrance end passes through a honeycomb formed from 3-inch metal conduit pipes 2 feet 6 inches in length into the experimental chamber. This honeycomb helps to straighten out the flow and prevent eddies in the wind.

The experimental chamber reaches from this honeycomb to the expanding trunk, but only the section midway between these points is utilized. The air after passing the model goes through a series of diagonal vanes and enters the expanding trunk. Here the velocity decreases with an increase of static pressure. The expansion in 11 feet of length is to a cylinder of 7 feet diameter. This cone expansion, in the English tunnel is only six feet on the 11 foot length. By expansion the pressure difference maintained by the four-bladed propeller is reduced and some turbulence in the wake avoided. The discharge from the propeller is received by a large perforated diffuser with the end opposite the propeller a blank wall. The function of this diffuser is to distribute the air into the room at a uniform rate and at a very low velocity. This is indeed accomplished for the area of the perforation in the diffuser is several times that of the tunnel and when a velocity of 30 mph an hour is maintained in the tunnel, the discharge from the diffuser is hardly noticeable.

A four bladed black walnut propeller of low pitch, revolving 600 r.p.m. will produce a wind of 25 miles per hour. The propeller is driven by a 10 horse power electric motor through a "silent" chain. The motor is mounted on a separate concrete foundation, as are likewise the aerodynamic balance and the tunnel proper, to avoid any variation in alignment caused by vibration. The sectional area of the tunnel permits of models of 18 inch span and as an extreme 24 inch span, to be tested at speeds from 5 to 40 miles per hour.

The control of the wind is by sensitive rheostats in the motor field and wind speeds may be kept constant as in the English tunnel to within ½ per cent. Measurement of velocity is by means of a calibrated "side plate" in the wall of the tunnel, recording on an alcohol manometer the difference of the pressure in the room and in the experimental part of the tunnel. These manometer readings were calibrated against a standard N. P. L. pitot tube to ascertain the true velocity.

The aerodynamical balance was constructed by the Cambridge Scientific Instrument Company, England, and is a counter-part of the English installation. Most model adjustments are possible from the outside without stopping the wind, thus greatly facilitating the experimental work. The balance is arranged so that complete data for the calculation of the stability coefficients for aeroplanes is obtainable.

While the laboratory is primarily for research work, investigations are conducted for private individuals or manufacturers at nominal charges.

It is interesting to note that the Curtiss Company has recently erected at Buffalo, under the direction of Dr. A. F. Zahm, a wind tunnel similar in construction to that of the N. P. L. and the Massachusetts Institute of Technology.

The detailed description of experimental methods and instruments employed will be dealt with in later sections of the course. A study of such methods will render more interesting and instructive the study of the aerodynamical data which has been collated from the work of these laboratories.

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Dynamical Stability of Aeroplanes

By Jerome C. Hunsaker, Eng.D.

Abstract of a Thesis submitted to the Faculty of The Massachusetts Institute of Technology

The following abstract[1] is the result of some three years' work in applied aerodynamics, while detailed by the Secretary of the Navy to the Massachusetts Institute of Technology. The preliminary work of erecting the wind tunnel and aerodynamical balance, design and calibration of instruments for velocity measurement, establishment of standard methods of experimentation and, finally, the investigation of the force of the wind upon aeroplane wings, rudders, bodies and other parts has been fully described elsewhere.[2] Study of aeroplane parts led naturally to the study of the aerodynamical properties of complete model aeroplanes which forms the substance of this thesis, the objects of which were:—

1. To determine the aerodynamical constants of two aeroplanes by means of model tests in the wind tunnel. One aeroplane was a standard military tractor with no claims to inherent stability in flight, the other a machine designed to possess some degree of inherent stability while departing as little as possible from standard practice as exemplified by the other.

2. To apply the aerodynamical constants so found in the dynamical equations of motion for the full scale aeroplanes in free flight and to examine the stability of the motion by the method of small oscillations, as first applied to the aeroplane by Bryan[3] and later extended by Bairstow.[4]

3. To compare the stability both laterally and longitudinally of the two aeroplane types chosen, with a view to tracing to the individual parts of each machine their effects upon the motion.

4. To attempt to formulate general qualitative conclusions which may assist aeroplane constructors to avoid instability or to provide a degree of stability.

5. To throw light upon the general problem of inherent dynamical stability.

Previous Work

The first rational theory of the dynamical stability of aeroplanes is due to Bryan whose work was extended and applied by Bairstow with wind tunnel tests. The late E. T. Busk of the Physical Staff of the Royal Aircraft Factory, England, applied Bairstow's model tests to an actual aeroplane and recently succeeded in perfecting an inherently stable aeroplane which could be flown "hands off." Neither the details of Busk's experiments nor of the type aeroplane developed by him have been disclosed by the British War Office, for obvious reasons.

Theoretical aspects of the problem have been discussed by Lanchester, Riessner, Crocco, Bothézat and others, but the only applications are those of Bairstow and Busk.

Laboratory Work

Wind tunnel testing of the models under investigation was carried on from June to September, 1915, by the writer and various students under his direction. The mathematical portions of the work were completed during the period October, 1915–March, 1916, with frequent consultation with Professor E. B. Wilson of the Department of Mathematics.

General Problem of Stability

The stable aeroplane model we designate by S and the unstable aeroplane by U. Both were tested in the same manner. The models were 1/24th scale, giving a span of about 18 inches. The wind tunnel has a section of 16 square feet and from previous tests, it was concluded that the influence of the walls was negligible for models of this size.

The application of model experiments to predict the aerodynamical properties of a full size aeroplane is well understood and the validity of such application has been repeatedly demonstrated. We assume that aerodynamical forces vary as the density of the air, as the square of a linear dimension of the model and as the square of the relative velocity. This is strictly true for inertia and eddy making resistance but not quite true for skin friction which varies less rapidly than the "square law" and must depend somewhat on the viscosity of the air. However, for engineering purposes, it is usual and probably sufficiently exact to assume the "square law" for all resistances.

The investigation is most conveniently discussed in two parts, the first dealing with the longitudinal motion involving pitching of the aeroplane and rising and sinking of its center of gravity combined with change of forward speed, and the second, with the lateral motion, which involves side-slipping, or skidding, combined with rolling and yawing to right and left.

Stability is distinguished as statical or dynamical. An aeroplane in free flight in still air must be driven at such a speed and kept at such an inclination of wings to wind that the weight is just sustained. The maintenance of this normal attitude is the technique of the aviator. When in its normal attitude the aeroplane, if properly balanced, is in equilibrium. In a statical sense, this equilibrium is stable if righting moments are called into play tending to return the aeroplane to its normal attitude if by any cause it is deviated therefrom. In general an aeroplane, if stable in a statical sense, will, when given an initial deviation, take up an oscillation which either may be damped out or may increase in amplitude. The aeroplane is dynamically stable if, and only if, these oscillations die out as time goes on, leaving the aeroplane in its original normal attitude. It is clear that statical stability must first be provided before the dynamical stability of a design can be examined. Also, without statical stability, there can be no dynamical stability inherent in the aeroplane.

Longitudinal Tests

The aeroplane model was mounted in the wind tunnel and the position, magnitude and direction of the resultant wind force determined for a series of attitudes in pitch corresponding to the highest and lowest flight velocities of the full scale aeroplane. This resultant force was then resolved into a couple acting at the center of gravity, and two component forces acting vertically and horizontally. From a consideration of the variation of vertical force or lift with change of angle, the corresponding speeds necessary to sustain the weight were estimated. Likewise, the equilibrium of the aeroplane was adjusted to be statically stable by change in horizontal tail surfaces. After three trials a tail setting was found which gave a proper balance.

With this disposition of surfaces, the rate of change of the component forces and of the couple was computed for use in the equations of motion. The radius of gyration of the aeroplane was estimated from the plans and the damping coefficient obtained by oscillating the model in pitch.

[1] Published in extenso as *Smithsonian Miscellaneous Collections*, Volume 62, Number 5, Washington, June, 1916.

[2] *Reports on Wind Tunnel Experiments in Aerodynamics*, Smithsonian Institution, *Miscellaneous Collections*, January 15, 1916.

[3] *Stability in Aviation*, ... *Engineering*, London, January 7 and 14, 1916.

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For the latter measurement, the model was mounted on a rocker arm made to oscillate by powerful spiral springs. The decrement of amplitude for various wind speeds was a measure of the damping of the pitching motion due to the air. Correction made for the damping due to pivot friction and to the wind on the bare apparatus, the logarithmic decrement was found to vary very nearly as the first power of the velocity as must be expected.

Longitudinal Motion

The equations of motion for the full scale aeroplane were then written down and the aerodynamical coefficients substituted. Confining the discussion to small oscillations about the equilibrium position, the longitudinal motion is represented by three simultaneous linear differential equations with constant coefficients of a well known type.

Solution by means of approximate factors shows that the motion may be considered as composed of two oscillations one of a period of the order of two seconds damped to half amplitude in 0.1 seconds, the other of period from 10 to 30 seconds not very strongly damped.

From a consideration of the coefficients, the short oscillation appears never to be of importance on ordinary aeroplanes, but the long oscillation, being only moderately damped, may cause trouble, especially for an aeroplane that flies with a large angle of incidence for the wings.

The calculation of the period and damping of the long oscillation was repeated for several speeds from highest to lowest corresponding to small and large angles of incidence with the results shown in the following table:

Aeroplane	S	S	S	S	U	U	U	U
Velocity, miles-hour	76.9	53.4	44.6	36.6	79	51.8	47	44.2
Incidence of wings	0°	2°	6°	10°	1°	7°	10°	14°
Period, seconds	34.7	17.6	15.8	10.32	34.0	10.7	13.7	11.5
Damp 50 per cent seconds	8.1	11.8	13.1	—	11.0	17.7	63.0	—
Double amplitude, seconds	—	—	—	24.7	—			24.7

Instability at Low Speed

It appears that the period becomes much more rapid at low speed, that at some critical speed the damping vanishes, and below this speed both aeroplanes become frankly unstable. This instability at extreme low speed is common to all aeroplanes and the only advantage of our "stable" aeroplane S is that its longitudinal motion is stable down to about 40 miles per hour while aeroplane U is stable only down to about 47 miles per hour.

The necessary existence of a critical velocity for any aeroplane where the longitudinal stability vanishes is believed to be shown here for the first time.

A study of the relative magnitudes of the coefficients for these typical aeroplanes leads to the conclusion that longitudinal instability at low speed is due, first, to the decrease in damping of the tail surfaces on account of the low speed and, secondly, to the decrease in rate of change of lifting force with change in attitude for high angles of incidence. Ordinarily, if an aeroplane heads up, the increased angle of incidence of the wings causes increased lift and the aeroplane rises and vice versa.

However, for an angle of about 15°, all known aeroplane wings reach a maximum lift and any further increase in incidence causes no increase in lift. This is a critical attitude for the wings. If an aeroplane flies very slowly it must be held at some large angle near this critical angle. If the machine is headed up, giving a greater angle of incidence, it will obtain from the air no greater lift and will not rise. It is "stalled." Indeed, some wings show a marked drop in lift for angles beyond the critical angle.

The coefficient that represents the rate of change of lift with angle of incidence is the predominating term in the expression which represents the damping of the long oscillation, and this coefficient vanishes near the critical angle. Consequently, if an aeroplane is to be stable and land at a relatively slow speed, it must not operate at too great an angle of incidence. To sustain its weight it should therefore have a greater wing area than another aeroplane which lands with about the critical angle for the wings.

The principal difference between aeroplanes S and U is that the former supports a weight of 3.55 pounds per square foot of wing area and the latter 5.2 pounds per square foot.

The following recommendations are made for an aeroplane to have its longitudinal motion damped at lower speeds than is usual in practice:

1. Provide large horizontal surfaces of long arm for damping the pitching.
2. Provide wings of such area that the slow speed does not require a great angle of incidence. Roughly the safe slow speed should not require more than 80 per cent. of the maximum lift of the wings.
3. Keep the longitudinal radius of gyration small by concentrating the principal weights.

Slowness in Pitching

It may be imagined that a dynamically stable aeroplane of rapid period might be so violent in its motion that the pilot would be shaken about to such an extent as to be hindered in the performance of his military duties of observation, gunfire, or bomb dropping. It appears that the expression representing the period of the long oscillation contains certain predominating coefficients, and a consideration of their magnitude leads to the following conclusions.

The natural period of pitching is increased by:

1. High speed of flight.
2. Large damping surfaces on the tail.
3. Small angle of incidence.
4. Small righting moments.

The righting moments which tend to restore the aeroplane to its normal attitude when it pitches are a measure of statical stability. If the statical stability is great the period of the oscillation will be short and the motion violent. Our desire is an aeroplane that has a gentle motion of slow period heavily damped. Dynamical stability is better given by heavy damping than by excessive stiffness or statical stability.

An ocean liner of too great stiffness (large metacentric height) is not suitable for passenger or cattle carrying service; it is preferable in ship design to give only enough metacentric height to insure that the vessel is never unstable and to damp the roll by generous bilge keels.

In a similar manner in aeroplane design, the theory indicates that it is preferable to give just enough statical stability to insure that the aeroplane is never unstable and to make the oscillation dynamically stable by the use of generous damping surface and large wings.

These remarks on damping versus stiffness apply with equal force to the latter motion of the aeroplane which is the subject of the second part of the thesis.

Lateral Motion

In a given longitudinal attitude proper for some fixed speed, the aeroplane model was tested in the wind tunnel when turned

to right and left away from the symmetrical position. For these oblique positions we measured the moment tending to turn the model back into the wind ("yawing" moment), the moment tending to tilt it over laterally ("banking" or rolling moment) and the transverse force tending to push the model to one side. From a series of such measurements the rate of change of yawing moment, rolling moment and lateral force with angle of yaw were estimated.

In the asymmetrical or lateral motion of the aeroplane in flight, the angular velocity in roll or yaw is considerably damped by surfaces moving through the air. Consequently, it was necessary to obtain damping coefficients for rolling and yawing from model tests on the oscillating beam in a manner similar to that employed to measure the damping of pitching.

When an aeroplane yaws rapidly the more rapidly moving wing lifts more than the other and a rolling moment is produced. Also when an aeroplane rolls, the downward moving wing has a greater angle of incidence than the other and, therefore, has more resistance to forward motion, producing a yawing moment. A method for calculating the rolling moment due to yawing and the yawing moment due to rolling has been devised.

The necessary aerodynamical coefficients being now at hand, and the radii of gyration in roll and yaw, the equations of motion for the asymmetrical motion may be set down. For small oscillations, these reduce to three linear differential equations with constant coefficients. The determinant formed from the coefficients may be factored by use of approximate methods and the motion compounded from that represented by each of three factors.

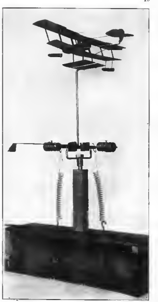
Spiral Dive

The first factor may correspond either to a damped or to an amplified motion, depending on whether the aeroplane be stable or unstable. At high speeds model S shows a subsidence damped to half amplitude in 10.4 seconds. At lower speeds this damping diminishes and at 37 miles per hour the motion becomes a divergence which doubles in amplitude in 7.2 seconds. Examination of the preponderating terms in the expression representing the motion shows that the aeroplane starts off on a spiral dive. There is a tendency on side slip or "skid" to the right, for example, for the aeroplane to head to the right toward the relative wind due to vertical fin surfaces on the tail acting as a weathervane. At the same time, due to spin in yaw, the machine banks to the right suitably for a right turn due to greater lift on the left or more rapidly moving wing. The increased bank increases the side slip, the yaw becomes more rapid and in turn the overbanking is magnified. The aeroplane starts off on a spiral dive and will spin with constantly increasing angular velocity unless the pilot intervene with his controls.

The spiral dive is corrected if the aeroplane have a preponderance of fin surface above the center of gravity or if the wing tips be raised. There must be such an arrangement of surfaces that when the aeroplane side slips to the right it banks suitably for a left turn. Then it will be restored to its normal attitude. A simple relation may be obtained involving four of the aerodynamical coefficients which, if positive, insures that spiral instability of this kind is not present.

It appears that spiral instability is caused by too much fin surface to the rear or too large a rudder, and by not enough fin surface above the center of gravity. A proper adjustment is easily obtained without sacrifice of desirable flying properties.

The aeroplane S is stable spirally at all reasonable speeds. It has a small rudder and wing tips raised about 1.6°. At



Oscillator Used for Investigating Dynamical Stability

Explanatory Note.—*To measure aerodynamic damping the model is placed in a horizontal position above the oscillator and meets the wind as in actual flight. A massive bracket pivoted above the two points shown supports the model. Fore-and-aft arms carry counter weights which are adjusted to give a reasonable natural period. The spiral springs bear in notches on the arms by means of knife edged shackles assuring that the motion shall be oscillatory. The assumed center of gravity location of the aeroplane model is arranged to be on the axis of rotation, the actual center of gravity of the apparatus being not considered. Friction is kept small by careful design of the pivots.*

The apparatus is fitted with a small reflecting prism by which a pencil of light is deflected towards a ground glass plate set in the roof of the tunnel. Fine lines spaced 0.2 inch are ruled on this plate. With the model at rest the beam of light is brought to a sharp focus on the line marked zero. By means of a trigger, the observer starts the oscillation of the model, and the spot of light is observed to oscillate across the scale. The time in which an oscillation is damped from an amplitude of say 8 to 1 divisions is observed and from this the logarithmic decrement of the oscillation is calculated. This must be numerically positive to insure that the oscillation dies out.

extreme low speed (when stalled), there is spiral instability caused by the righting moment due to side slip becoming small. The effect of the slight dihedral angle of the wings is not of much assistance at large angles of incidence and it may be preferable to fit true vertical fin surface, whose stabilizing effect should be independent of attitude

Aeroplane U is spirally unstable at high speeds It has no rise of wing tips nor vertical surface above the center of gravity and has a very deep body giving the effect of a rear vertical fin

Rolling

The second factor in the equation of motion represents a rolling of the aeroplane which is so heavily damped by the wide spreading wings as to be ordinarily of no consequence In the extreme case of a "stalled" aeroplane, the damping of the roll vanishes because the downward moving wing has no more lift than the other. Here we may expect trouble, and frequent accidents to stalled aeroplanes indicate that the pilot's lateral control by ailerons also becomes inoperative At reasonable flying speeds this factor should not lead to any instability.

Dutch Roll

The third element in the motion is a yawing to right and left of the course combined with rolling The motion is oscillatory of period from 5 to 12 seconds, which may or may not be damped. We may imagine an aeroplane which is spirally stable to yaw to the right accidentally. Due to fin surface above the center of gravity it banks in a manner proper for a right turn, but the roll is resisted by the damping of the wings. The turn is assisted by the increased resistance of the downward moving wing, but eventually the weathercock effect of fin surface at the tail turns it back into the original course. As the machine swings back to her course, the bank flattens out But, due to angular momentum, she swings out to the left and banks for a left turn. This swinging to right and left is accompanied by rolling and some side slipping

The analogy to the "Dutch Roll" or "Outer Edge" in ice-skating is obvious. If the skater lean too far out on his swings he may fall, and in the same manner if the aeroplane bank too much a slight puff of wind may capsize it.

The motion in the "Dutch Roll" is stable provided there be sufficient vertical fin surface on the tail and not too much fin surface above the center of gravity These requirements conflict with those previously stated for spiral stability and a compromise must be made. Overcorrection of spiral instability may produce instability in the "Dutch Roll" and vice versa. Fortunately, the damping of rolling by the wings is helpful in both cases, and it appears possible to obtain that nice adjustment of surfaces which will render both motions stable

Model S was stable in the "Dutch Roll" at all speeds, having a period from 6 to 12 seconds, and the initial amplitude damped 50 per cent in from 1.5 to 6 seconds. Model U was stable in this respect except at low speed when it showed a period of 6 seconds and the initial amplitude was doubled in 8 seconds. Here the aeroplane was practically "stalled" and the damping of the roll due to the wings was only one quarter of its value at high speed.

General Conclusions

It is believed that the majority of modern aeroplanes are spirally unstable but stable in the Dutch Roll. Furthermore it appears to be a simple matter so to adjust surfaces that any aeroplane can be made completely stable without sacrifice in speed or climb. At extreme low speed an aeroplane must be unstable in its longitudinal motion but need not be unstable laterally.

The degree of stability to provide in a given case cannot be determined from mechanical considerations, but certain general conclusions may be indicated For example, the comfort of the pilot must be a first consideration and for this reason the righting moments giving statical stability should be small, the period of the aeroplane can then be made relatively slow, and if the damping is adequate, the free oscillations will be stable

The theory is applied here only to flight in still air Obviously the air is never still, and the aeroplane must finally be judged from its behavior in gusts. An inherently stable aeroplane tends to preserve its normal attitude with relation to the relative wind, and if the velocity and direction of the relative wind change in an irregular manner, the stable aeroplane will tend to follow in an effort to preserve the same relative air speed and longitudinal attitude The result will be to force a motion of the aeroplane which will be more violent the greater the statical stability. Consequently in rough air an aeroplane very stable statically is unsuitable as a gun platform and for many other military purposes. A machine whose inherent statical stability is slight or nearly neutral should be slow to respond to gusts.

The stable aeroplane, if the pilot abandon his controls, tends to fly in such a manner that the relative air speed and attitude remain constant In good weather, the pilot may, therefore, abandon his controls at intervals to make observations which ordinarily would require an assistant as observer However, this very tendency of the machine to adjust its flight path may prove a source of danger when the pilot wishes to make a landing in a small field Here the machine, if struck by wind gusts, will attempt to "take charge" in resistance to the pilot's efforts to direct it. A very stable aeroplane is not, therefore, so completely under the pilot's control as one whose stability is slight

For the determination of the degree of stability suitable for military aeroplanes we must finally depend upon the preferences of pilots A knowledge of the natural periods and damping coefficients should then furnish a means for fixing the verdict of experience, so that in future the desired degree of stability may be provided

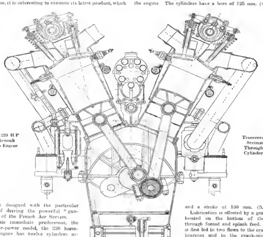
Considerations of theory indicate that a slight degree of statical stability combined with the maximum of damping give an aeroplane slow periods of oscillation and a dynamically stable motion, with little ill effect upon performance or controlability

The following table summarizes the results obtained for the lateral motion:

Aeroplane	S	S	S	U	U
Wing Area square feet	464	—	—	384	—
Span feet	40 2	—	—	36	—
Chord feet	5 77	—	—	5 3	—
Weight pounds	1600	—	—	1800	
Pounds per square foot	3 55	—	—	5 2	
Rise of Wings	1 63°		—	0°	
Angle of Incidence	0°	8°	12°	1°	15°
Velocity miles	75 9	44 0	38 0	78 9	43 6
Spiral Motion.					
Damp 50 per cent seconds	10 4	2 7	—	—	3 3
Double seconds	—	—	7 0	28 0	—
Dutch Roll					
Period seconds	5 9	10 7	12.0	5 2	5 7
Damp 50 per cent seconds	1 4	1 2	0 8	1 8	—
Double seconds	—	—	—	—	7 7

The Two Hundred and Twenty Horse-power Renault Aero Engine

One of the most successful foreign aero engines of great power is the twelve cylinder V-type Renault engine which is rated to develop 220 horse-power at a normal engine speed of 1,200 revolutions per minute. As the Renault Company of France was the first concern to produce a V-type aero engine, it is interesting to examine its latest product, which has been designed with the particular object of driving the powerful "gun-planes" of the French Air Service.



The 220 H P Renault Aero Engine

Transverse Section Through Cylinders

Like its immediate predecessor, the 100 horse-power model, the 220 horse-power engine has twelve cylinders arranged in two rows of sixes so as to form an angle, or V, of 60 degrees The cylinders, made of high grade steel, are mounted separately on the base chamber, and are surrounded in pairs by autogeneously welded steel water-jackets. In each pair of opposite cylinders, it is arranged that one piston rod is connected directly to the crank pin, while the other is attached to a bearing on a projection from the first The crank-shaft is supported by four bearings lined with anti-friction metal and its propeller end is provided with double thrust ball bearings, so that either a tractor or a pusher air-screw may be mounted.

The valves are of the overhead type and have a very large diameter, which secures high volumetric efficiency. They are operated by individual rocker-arms and by two overhead cam-shafts, one for each row of cylinders, which are driven through bevel gears from a vertical shaft and two inclined shafts at the anti-propeller end of the engine. Each cam-shaft is enclosed in an oil-tight casing which is bolted to the cylinder heads and a ventilating pipe is provided for each cam-shaft at the propeller end. The intake valves are on the outside and the exhaust valves on the inside of the cylinders, the exhaust being led through a silencer mounted on top of the engine The cylinders have a bore of 125 mm. (4.92 in.) and a stroke of 150 mm. (5.90 in.),

Lubrication is effected by a gear pump, located on the bottom of the sump, through forced and splash feed. The oil is first led in two flows to the crank-shaft bearings and to the crank-pins The cylinders are lubricated by splash Furthermore, the oil is driven to the magneto driving gears, to the vertical and inclined shafts driving the cam-shafts, and finally into the cam-shaft casings. The wastage of oil is compensated by an auxiliary gear pump, mounted below the main pump, which draws the oil from the main tank. Both pumps are jointly operated through a worm-drive by a horizontal shaft, which is driven by the crank shaft through a vertical shaft with a bevel gear.

There are two automatic carburetors, one mounted on the outer side of each row of cylinders, each carburetor feeding its individual row, through a two-branch tubing, in two sets of three cylinders. The volume of mixture admitted into the cylinders can be manually controlled by a throttle valve. The mixture itself is slightly heated by a water-jacket surrounding the carburetors and tubing, through which the water of the cooling system circulates A proper mixture is automat-

ically secured through a number of ports in the air-chamber of the carburetor. These are fitted with annular valves whose movement is regulated by the greater or lesser force of the aspiration.

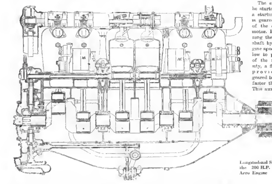
The cooling of the engine is secured, not as on previous models through an air blower, but through a centrifugal water pump which is driven through bevel gears from a vertical shaft actuated by the engine. The water-jackets of each row of cylinders are inter-connected by short lengths of rubber hose and communicate with two separate radiators through conventional inlets and outlets.

The ignition is double and is effected by four high tension magnetos, which are driven through bevel gears by the vertical shaft actuating the cam-shafts. Each cylinder is fitted with two spark plugs. The magnetos are mounted in two twin-groups between the cylinder rows, each group *MM'* being operated by a common gear. One magneto ignites the inner spark plugs of one cylinder row, while the other magneto ignites the outer spark plugs of the opposite cylinder row. Should, therefore, one magneto of either group break down, ignition will still be fully provided by the other magneto group.

The engine may be started either by spinning the propeller or by means of a starting crank combined with an auxiliary magneto or by a compressed air engine. The latter follows closely the design of conventional aero engines of the radial, non-revolving type, except that it is entirely made of aluminum. The cylinders are cast integrally with the crank case. The pistons are leather lined and their connecting rods are directly fixed to a single crank.

The motor is fed from a cylinder containing sufficient compressed air for ten startings. The air reaches the cylinders by way of an air chamber through a rotating distributor which is geared to the crank and is fitted with six port-holes communicating with the cylinders by means of radial channels cast *en bloc*. The rotation of the distributor effects the intake by connecting the port-holes with the circular channels and the exhaust is led through the same channels back to the distributor, wherefrom another series of port-holes lead to an annular chamber communicating with the atmosphere. In order to accelerate the exhaust, two additional port-holes are drilled on each cylinder at the lowest position of the piston stroke.

The servo-motor is connected with engine as follows. The crank-shaft of the engine is coupled to a box fitted with three pawls which grip, by means of springs, a ratchet coupled to the crank of the servo-motor. When the latter is started, the pawls and ratchet are connected and the engine crank shaft will be spun till it acquires sufficient speed for insuring proper ignition. As soon as this is obtained, the pilot stops the flow of compressed air and the pawls automatically disconnect themselves from the ratchet through centrifugal force.



Longitudinal Section of the 200 H.P. Renault Aero Engine

The engine can also be started by means of a starting crank which is geared to the crank of the compressed air motor. Because in spinning the engine crank-shaft by hand, the engine speed would be too low to produce sparks of the required intensity, a fifth magneto is provided which is geared to turn ten times faster than the engine. This auxiliary magneto produces two sparks at a time, or about forty sparks for two complete revolutions of the engine. Its high tension wire is connected with the distributors of the four main magnetos, but as the auxiliary magneto and the starting crank are coupled to the crank of the servo-motor, and therefore with the pawl and-ratchet transmission, it will stop producing sparks as soon as the engine has started.

According to the well-known formula

$$P D = D^2 \, 0.7854 \, S \, N$$

the cylinder capacity (total piston displacement) is 1348 cu. in.

Dirigibles for Sport

A sportsman's air-ship 150 feet long and not over 45 feet high, equipped with an 80 horse-power engine that should drive it a speed of from 45 to 50 miles per hour can be constructed at a cost not exceeding $15,000 according to a recent estimate.

Review of Technical Press, Engineering and Scientific Publications

MODERN GERMAN AEROPLANES

By Jean Lagorgette

Abstract by E. P. Warner

The author is careful to state that the data he submits has been obtained mainly from a personal inspection of captured German machines, which were certainly in use in March of this year. He points out that German aeroplanes have, since the war began, tended more and more towards uniformity, both because of the advantages which standardization brings in the making of repairs, supply of spare parts, etc., and because the complete subordination of individualism to the common welfare makes each constructor eager to adopt the best points of every other design, instead of seeking to make his machine different from the rest. This spirit was not so noticeable before the war, and it is only since its outbreak that designs have been gradually modified until they all approach each other closely.

The giant machines, of which so much has been heard, are said to be seldom seen anywhere along the front. The Germans have preferred to put their trust in rigid dirigibles, so far as heavy work is concerned, but this is a condition which is likely to change at any time, as the importance of the heavily armed fighting machine is being increasingly realized.

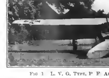


Fig. 1. L. V. G. Type, P. F. Ailerons Cut Away.

At the inception of the war the Taube, in its numerous forms, was the most characteristic feature of German aviation, although biplanes of Teutonic origin, under the skilful guidance of Landmann and Oelrichs, had made remarkable records. The most distinctive feature of these biplanes was the excessive sweep-back of the wings, which has disappeared in more recent machines.

The German willingness to borrow extends not only to other constructors of their own nationality, but also to foreigners, so that the "deadly Fokker" and other successful machines are to-day said to be little more than copies, either of one French machine, or a mixture of features selected from a variety of machines. The present typical German biplanes (Aviatik, Albatros, L. V. G., etc.) are tractors. Before the war there were a number of pushers, more or less inspired by the Farman, but they were soon abandoned.

A tendency to decrease the length of the fuselage has been manifested. The total length of the machines of 1914 averaged about 30 ft., a figure which has been shortened to 26 ft. The span, too, has decreased, although in a slightly smaller proportion, the change being from 47 to 42 ft. Due to the shortened fuselage very large fixed stabilizing planes are used and the German machines, seen in flight, always appear to have the tail and wings remarkably close together. It is very noteworthy that the Germans have been able to use such short bodies successfully.

The normal incidence is about 4.5°, very nearly the angle of maximum lift-drift ratio, and the angle and curvature of the wing are approximately constant from tip to tip. Two years ago it was the custom to employ a lower wing of much less span than the upper, but they are now nearly or quite equal. Many different forms have been tried for the wings, but it is now the general rule to use a nearly rectangular form, with the entering and trailing edges perpendicular to the line of flight. The exceptions to this are the L. V. G. of Fig. 1, which has the entering edge slightly sloped back, causing the chord to decrease from root to tip, and the D. F. W. of Fig. 2, which still employs the peculiarly back-swept wings which gave it the nickname of "banana." The sweeping back of the wings in a straight line, which was almost universal in 1914, has given way to a slight dihedral as a means of obtaining stability. The aspect ratio ranges from 6.7 to 7.2. An unusual feature of several German machines is the small gap between the wings. The gap is nearly always less than the chord, and in the larger Albatros it is more than 15% less.

Ailerons are used on all types, and they are sometimes of very peculiar design. They are divided in form at mid-section and so warped as to produce the effect of a slightly upturned trailing edge. This construction is illustrated in Fig. 3, and is probably designed to give efficient action in both the up and down motion of the aileron.

The inter-plane bracing has been much reduced in recent models and is well illustrated in Fig. 4. On most of the machines in use at present there are 8 metallic struts, connected by a simple rectangular system of wiring, in place of the complicated cantilever truss for which German construction used to be noted.

Fig. 2. D. F. W. "Banana."

Fig. 3 Aviatik, Type P Warped Ailerons, Balanced Rudder

The connection from the fuselage to the upper wing is made through a pair of supports in the shape of an inverted V These offer no more resistance than the old system of four short vertical struts, and are much stronger The wings are now covered with a yellowish cloth, and doped with a transparent varnish of a bluish tint, which makes the wing more difficult to pick out against a blue sky

Fig. 4 L. V. G., Type D. 9, Exhaust Above Honey Comb Radiator in Front of Upper Wing

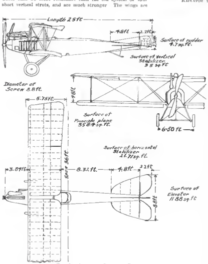


Fig 5 Albatros Scouting Biplane.

In the Albatros scouting biplane of Figs 5 and 6, a thoroughly representative machine, the tails consist of a large stabilizing plane, generally of nearly semi-circular form, followed by two elevator flaps The surface of the fixed portion is about 24 sq ft, that of the elevators 13 sq ft. The contour is very much like that of the old Nieuport monoplane. The rudder, too, is approximately semi-circular, 5 sq ft. in area, and is preceded by a triangular fin of 4 sq ft. The Aviatik of Fig 3 employs a most peculiar arrangement, having the characteristic triangular fin, but following it with a balanced rudder whose axis is some distance behind the trailing edge of the fin, so that, when the rudder is turned, there is a discontinuity between the two surfaces a thing which seems extremely undesirable, as it must greatly enhance the eddy affect about the rear

The fuselages are all rectangular in section, and are generally more curved on the lower than on the upper surface The Aviatik diverges from standard practice here in that the forward portion of the fuselage and engine cover instead of being composed of smoothly curved surfaces, is almost exactly pyramidal in form, as shown in Fig 7

Before the war, the landing gear favored by the Germans was that of the Etrich Taube, a form not unlike Bleriot's This has been abandoned in favor of the simple V chassis constructed largely of metal. Rubber shock absorbers are used, and the track is large (from 6 to 8 ft.).

All the German biplanes use 6-cylinder fixed motors, mounted with the cylinder heads protruding up out of the fuselage The exhaust pipe is of unusual form, the gas being carried straight up from the manifold and discharged above the top plane (See Fig. 4) Water cooling is universal, and the radiator, inclined toward the rear, is mounted just below the top plane in several cases, notably the L. V. G. and Aviatik. In this disposition, the usual honeycomb radiator is used, and the total cooling surface for a 160 h.p. engine is roughly 73 sq ft In other machines, the Hazet radiator is still found. The tanks are placed under the seat or at each side of the observer and fuel is pumped by hand to an auxiliary tank under the top plane, whence it feeds by gravity, or else a small mechanically operated pump forces the fuel directly to the engine

All the machines which we are discussing have two seats in tandem, but there is no agreement as to whether the passenger should sit in front of or behind the pilot The controls are of the usual type, with wheel and foot-bar Dual control is not employed. German military experience apparently showing this to be an unnecessary complication —*L'Aérophile* (March, 1916)

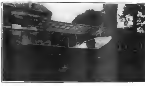


Fig. 7 Aviatik. Engine Cover of Pyramid Form

Fig. 6. Albatros, Scouting Biplane.

RECENT WORK AT THE N. P. L.

In conjunction with the British Admiralty and the Royal Aircraft Factory the National Physical Laboratory has considerably enlarged its equipment and staff Two additional wind tunnels have been erected, one of 7 feet and the other of 4 feet diameter. Recent experiments have dealt with the effect of fin area of airship models on the restoring couples which follow a displacement; the stability of kite-balloons; the modifications required in an aeroplane wing for a machine which is to fly at high speed and to alight at a low speed. The form of aeroplane bodies and the disposition of guns have been studied. Mathematical analysis has been extended to the examination of stability in circling flight, horizontal or spiral The efficiency of radiators for aeroplanes and the resistance and stability of aerials are other problems which are being dealt with

A NEW TYPE OF LANDING GEAR

A new type of combined land and water chassis has been invented by Lieutenant Angström of the Swedish Flying Corps. Two floats are attached to the chassis, one on either side, and to each float is rigidly secured the axle of a wheel, the wheel projecting over the inner edge of the float for nearly half its diameter The floats are hinged so as to turn in an angle of 90 degrees When adjusted for hydroplaning, the floats are hung so that the wheels are in a horizontal position, as shown in the front and side elevations in Fig. 1

When it is desired to use land gear, the floats are rotated through an angle of 90 degrees, bringing the wheels into the vertical plane, as is illustrated in Fig. 2. The axes of rotation lie in the center of the upper surfaces of the floats and the change is carried out by means of wires attached to the upper edges of the floats, and passing over pulleys. At the cost of a slight additional complication, the wheels may be sprung into position by means of coil springs, as shown in Fig 3.

The inventor suggests the use of a triangular linkage, with one extensible side, similar to the chassis of the Bleriot XI, but lying in the transverse instead of the longitudinal plane.—*Flight* (May 11, 1916).

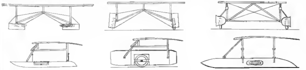


Fig 1 Fig. 2. Fig. 3

A New Type of Landing Gear.

Book Reviews

AIRCRAFT IN WARFARE

By F W Lanchester

(Constable London. Price $4 00 Pp 222)

The book is mainly compiled from a series of articles in *Engineering* covering a period from September to December, 1914.

It contains a number of very interesting photographs of R A. F. machines, including the inherently stable B. E. 2c and the R A F. Type F E 2, designed to carry a gun weight of 300 lbs , also the fast Sopwith Scout, the White and Thompson flying boat, and other well known machines. The collection forms a very good compendium of British practice

The author speaks of the modern aeroplane as "flying itself," and inherently stable machines are apparently taken far granted in British practice Considering the discharge of an aerial torpedo which may constitute one quarter of the gross weight of the machine the author states that with a dynamically stable machine the disturbance due to the release of the torpedo is well within permissible limits, and the extent of the initial undulation is the same as that produced by an adverse wind gust of ten miles per hour. The only condition to be observed is that the center of gravity of the torpedo should be approximately in the same vertical line as the center of gravity of the whole machine

Opinion in this country is still divided as to the value of the inherently stable machine but the authoritative views of Mr Lanchester, based on close observation of performance in the war, justify the view that such machines are indispensable

The author discusses very carefully the question of armament, and considers the armament required at flights of varying altitudes. Two thousand feet is taken as representing the lowest altitude limit of ordinary military flight, and with an armament of three mm. steel in all its vitals, a machine at this altitude would be extremely difficult to bring down

The chapters on armament are worth very serious study

Consideration of the Lewis quickfiring gun, bomb throwing, steel darts, and of torpedo discharge make very interesting reading.

The Tactics of the Aeroplane are dealt with in scientific and masterly fashion. Aircraft is considered in the service of the Navy, in attacking submarines and dirigibles and in the service of the Army There is a very skilful and plausible demonstration of what the author calls the law of N^2: the fighting strength of a force is equal to the square of its numerical strength multiplied by the fighting value of its individual units. Such a law confirms the concentration of force as practised by commanders throughout the ages, whether on sea or land.

The book makes easy and fascinating reading, its utility to all interested in the military development of the aeroplane is apparent, and it would serve as a stimulus to any one interested in aeronautics.

MECHANICAL ENGINEERS' HANDBOOK

Lionel S. Marks, Editor-in-Chief

(McGraw Hill Book Co Price $5 00 Pp 1770)

This monumental work is based on the German Hütte, now in its twenty-second edition It is divided into fifteen sections, each of which has been handled by a number of most eminent American specialists, and covers the whole field of mechanical engineering

The information is concise, excellently presented, and complete. Much of it is, of course, hardly of interest to the aeronautical engineer. But, on the other hand, it contains a wealth of information on materials, alloys, timber, strength of materials, machine shop practice, mechanics and mathematics, engineering measurements, patents, etc., which the aeroplane designer or constructor will find of immediate utility.

The section on Aeronautics, though somewhat condensed, deals with resistance of bodies, struts, cables, wing coefficients, propellers, etc , summarizes standard practice for the main dimensions of a machine, with a number of useful rules, and gives directions for preliminary design and for performance curves.

No better handbook could be selected by the aeronautical engineer as his standby, either for general or more specialized aerodynamical data.

BOOKS RECEIVED

AVIATION An Introduction to the Elements of Flight. By Algernon E Berriman 360 pp Price, $4.00 George H Doran Company, New York

AIRCRAFT IN WAR. By J M Spaight 172 pp Price, $2 00. The Macmillan Company, New York

THE AIRMAN. Experiences While Obtaining a Brevet in France By Captain C Mellor, R.E. 123 pp Price, $1 00 John Lane Company, New York.

AEROPLANES IN GUSTS. Soaring Flight and the Stability of Aeroplanes. By S Z. Walkden 272 pp. Price, $4 00. Spon & Chamberlain, New York.

INDUSTRIAL PREPAREDNESS By C. E Knoeppel 145 pp Price, $1 00. The Engineering Magazine Company, New York

NATURAL STABILITY AND THE PARACHUTE PRINCIPLE IN AEROPLANES By W Le Maitre. 46 pp. Price, 50 cents. Spon & Chamberlain, New York.

Aeronautical Patents

ISSUED JULY 4, 1916

1,189,302. Filed March 30, 1914 To William E Somerville Coal City Ill. Biplane with pivoted wings.

1,189,382 Filed Sept 28, 1915 To Horace S Puck, Rochester N Y Aerial dart with explosive charge and bullet nose and guiding vanes.

1,189,810 Filed Aug 13, 1912. To Albert H Morris, New York N Y Aeroplane with series of wings (3) placed horizontally on opposite sides of fuselage

1,189,012 Filed Aug 12 1915 To Frank Narohe, New York N Y Flying boat with wheels, four movable triangular wings one each side geared to central shaft, to revolve in flight.

1,189 816 Filed Feb. 11, 1916 To Joseph Thompson Parker Washington, D C Armored aeroplane device. Gun arranged to fire through hollow propeller shaft and aimed by maneuvering aeroplane

1 189 880 Filed April 28, 1913 To Jefferson M Gardner New London Conn Airship car with tilting sleeve

1,190 178. Filed Jan 28, 1914 To Gustav G Lelevier Douglas, Ariz. Biplane with parachute attachment

1 190,248 Filed April 14, 1914 To Denis F Cashman and Christ. A Brownfield Zanesville O Attachment for changing angle of aeroplane wings.

ISSUED JULY 11 1916

1 191 077 Filed Aug 20 1915. To Oscar Hermanson, New York N Y Device for keeping airships afloat

1 190 343. Filed July 20, 1914 To Claude U Tyrrell Chicago Ill. Folding wing monoplane toy

1,190 397 Filed Aug 9 1916 To John W Treeman Oklahoma Okla A Helicopter airship.

1,190,321 Filed July 9 1915 To William Benjamin Pusey. Boise Idaho Aeroplane wing surface

1 190 376 Filed Oct. 2 1913 To Fred J Chlone La Salle Ill Safety balloon attachment for aeroplanes.

1,190,374 Filed April 1 1912 To Frank Capdevilla New York N Y Control tillers with locking device

1,190 278 Filed March 31 1916 To John Percival Clark Hendon England Articulated aeroplane wing with movable forward edge

ISSUED JULY 18 1916

1 191 375 Filed Feb. 12, 1916 To Sylvanus S Van Kearce Aberdeen South Dakota Torpedo dropping mechanism for airships

1,191 448 Filed Oct. 17 1914 To Anthony Maruca Aetta Pa. Monoplane with dihedral angle construction and warpable wing tips.

1 191 501 Filed March 23 1914 To Mark A Dees St. Louis Mo. Helicopter with cylindrical body and automatically collapsible parachute

The Wright, Model L, Light Reconnaissance Aeroplane

The Wright, Model L, Light Scout, a one-man tractor, has been designed to fulfill a demand for high speed, moderate power, light weight, economical upkeep, and ability to fly at very low speeds, at a fair purchase price This machine gets off the ground very quickly, even at slow speed, and has a range from 35 to 81 miles an hour, as measured by the Wright Company on the field, the latter speed being obtained at a test in which half a mile was registered in 22 seconds. An observer gets the novel impression that the machine is flying without effort, it seems to verily float, and it drives like an automobile With the motor well throttled down, the machine still flies at a safe angle.

WRIGHT, MODEL L, SCOUT

While designed primarily for military scouting, on lines laid down by a representative of the War Department, its small dimensions and light weight make it a runabout particularly suitable for the sportsman owner There is simplicity expressed in every detail, and in the event of repairs becoming necessary these can be made with the minimum of expense in time and money Its quick rising ability makes it available on fields where a larger machine would be out of the question

The photograph that is reproduced herewith gives a good idea of the general style and appearance of this machine.

WRIGHT, MODEL L, SCOUT PLAN

The details of construction are indicated on the drawings of the plan, and front and side elevations, which scale approximately 8.7 feet to one inch The following description of construction is of interest.

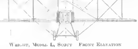
SUPPORTING PLANES.—The upper plane is in three sections and the lower in two, interchangeable, in a vertical direction The wings are readily demountable from the engine section for shipping or motor haul. The guy wires are solid steel wires, not cable, cut to length No turnbuckles are used in guying the main cell The wires, which are double where the load comes, are formed with eyes, securely soldered, which loop over hook-plates under the strut-ends. By taking out a small bolt which runs through the strut and its fitting, the struts are slipped out, releasing the wires from the hook-plates.

The solid struts are spruce, with very little head resistance. These are of the same thin and deep dimensions throughout, save at the ends where they taper to the fittings. At each side of the fuselage is a narrow surface to which the lower wings attach The struts in the engine section run from these small planes to the upper plane in this section.

The wings are thus entirely separate and individual units There is no wing surface under the fuselage Spruce lateral spars are of ample dimensions. The ribs are solid spruce, I-beam section with the webs drilled The fabric is Irish linen, doped and varnished. Spruce strips are attached to the top side of each rib to hold the cloth in place, and the wings are adequately wired internally

SUPPLEMENTARY PLANES.—There is a semi-circular fixed stabilizer, non lifting, to which the elevator flaps are hinged.

CONTROLS.—Lateral equilibrium is maintained by double-acting ailerons cut out of both upper and lower planes, hinged to the rear lateral spars These have a slight curve and normally are actual portions of the wings. A spruce spacer strut connects the upper and lower ailerons. The control cables run from the spacer strut-ends over pulleys at the upper and lower extremities of the adjacent plane struts and along the wings to the steering column. The cable from the lower aileron runs to the top of the strut and vice versa. The ample surface of the ailerons insures very easy control The balanced rudder is operated from a rudder bar by cables running into and through the fuselage to the steering wheel. The elevator flaps are operated by cables from the masts through the fuselage to the wheel



WRIGHT, MODEL L, SCOUT FRONT ELEVATION

The steering ed used is the standard Wright. Turning the wheel right or left operates the ailerons, rocking the wheel and its supporting column fore and aft operates the elevators. An aluminum hand lever turns the rudder with very little pressure Gripping the wheel and the lever at the same time in one hand causes the rudder to turn simultaneously with the operation of the ailerons, otherwise the ailerons may be operated entirely independently

The aileron and rudder cables end in short chains which run over sprockets on the steering column The aileron sprocket is rigidly attached to the axis of the steering wheel and the rudder sprocket is free on the same shaft. Gripping the rudder lever with the wheel in one hand obviously rotates the two sprockets simultaneously.

FUSELAGE.—The fuselage is of usual box girder construction, strong wire braced The nose is covered with aluminum, with very large doors to give access to the motor The balance is covered with linen, doped, painted gray and varnished The deck is of veneer, linen covered The body tapers to a vertical knife edge at the rear. The rudder is hinged to the rearmost strut of the fuselage Where control cables pass into the fuselage, brass eyelets are used In the fuselage no bolts pass through spars, a special fitting obviating this practice The longitudinal spars are ash and the vertical and horizontal ones are spruce The pilot sits in a comfortable pit under the trailing edge of the upper wing

WRIGHT, MODEL L, SCOUT SIDE ELEVATION

In front of him is a dash with gasoline gauge, clock, aneroid, gas cock, pressure gauge and slip indicator mounted thereon Pressure in the tank is maintained by hand pump.

INCIDENCE INDICATOR.—On a strut is fastened the Wright angle of incidence indicator, which gives at all times the angle of the chord of the planes with respect to the air currents through which the machine is flying and is entirely independent of gravity.

POWER PLANT.—The motor is the latest Wright, six cylinders, 4½ by 4½ inch bore and stroke, rated at 70 horsepower The tractor screw, of high pitch, is mounted on a short shaft which forms part of the Wright flexible drive The engine shaft has a light flywheel keyed to it Concentric with this is a steel disc to which the propeller shaft is keyed Eight stud bolts project from the disc and the flywheel respectively and over each pair of studs is a short but very heavy endless rubber band These bands transmit the full power of the motor to the propeller and absorb vibration and sudden strains on propeller or engine shaft

The gasoline tank is to the rear of the motor, inclosed in the fuselage. The entire engine is covered in by the fuselage, the exhaust pipes sticking through holes in the deck. A flat tube radiator is on either side of the nose of the fuselage and these are quickly demountable by unfastening retaining straps which hold them to plates attached to the framing. The hose connections can be quickly taken off

RUNNING GEAR.—The chassis is very simple. The axle is of steel tube. The wire wheels are 26 inches by 4 inches, liberal for the machine The spokes are covered by aluminum discs The chassis struts are of ash. The weight of the machine is sprung from the axle by rubber band shock absorbers

GENERAL INFORMATION.—The span is 29 feet, gap 5 feet 9 inches, chord 6 feet, area of main planes 334 square feet, length overall 24 feet, weight empty 850 pounds A useful load of 650 pounds may be carried, including 12 gallons of fuel for two hours' flying, water, oil, pilot, etc The gross weight per square foot, including ailerons, is 4.5 pounds

OUR NEW NAVAL ANTI-AIRCRAFT GUNS

Photo by N Y Herald Service

The battleships Texas, Pennsylvania and Nevada of the Atlantic Fleet are being equipped with the new anti-aircraft guns shown in the above photograph, and before long eighteen other battleships and cruisers in the United States Navy will be provided with these weapons, which are said by naval officers to be the most efficient guns yet made for use against aircraft.

The new gun has been developed through experiments conducted in the Bureau of Ordnance during the past three years under the direction of Rear Admiral Strauss, and special credit for the design is given to R G Marvell, Commander A. L. Norton, retired, and Commander C. B McVay

The weapon is a three-inch rifle, fifty calibres long, which according to claims, will hurl shells 27,000 feet into the air at an angle of 90 degrees, at rapid fire rates The careful tests made on several of these guns at the Indian Head proving grounds have convinced naval officers that they are thoroughly efficient, coming up fully to the predictions and expectations of the designers.

The plans of the Navy Department call for the placing of two of these guns on each battleship, riveting them fore and aft on the rear stands of the gun turrets so as to secure the best possible firing radius. By this arrangement, the guns can be swung into position for firing in all directions

With the Aero Clubs

The Aero Club of America

Acting upon request of Secretary of War Baker, the Executive Committee of the Aero Club of America has submitted to the War Department an elaborate program for organizing the nation's aerial forces This program is to provide for the following items

1—One aero squadron of twelve machines for each of the twelve militia divisions, as was provided for in the organization tables of 1914, but could not be carried out for lack of funds Each squadron is to cost $800,000, making a total of $9,600,000

2—One aero squadron for each of the four army divisions, at $800,000 per squadron, a total of $3,200,000

3.—Two aero squadrons for each of the three coast artillery districts, at $800,000 per squadron, a total of $4,800,000

4.—At least 450 machines for training aviators at a total cost of $4,000 375

5.—For establishing ten aviation schools, $5,000,000

6—A number of dirigible and kite balloons for service with the Army, costing a total of $2,000,000

7—A competition for aero engines, automatic stabilizers and other safety devices, to cost a total of $1,000,000.

In addition to the above program, which provides for the needs of the United States air services to be created, the Executive Committee of the club has outlined the following plans which, according to its own words, "if carried out, will give fairly substantial aeronautical organizations to the Army, Navy and Militia, and constitute a good step towards placing the United States in the safe position aerially"

This second program of the Aero Club of America calls for:

1—An increase of the Army appropriation from the $1,222,000 now provided for, to $5,000,000, which is the amount required to organize, equip and maintain for one year five aero squadrons, including the cost of training and pay to officers and mechanics A detailed cost of one aero squadron is given in the estimate shown below

2—An increase of the National Guard appropriation for training officers from the $76,000 now provided for to $1,000,000, which is the amount required for training 160 militia officers and providing the necessary flying material. To this should be added the cost of establishing six aviation schools, building of sheds, machine shops, etc.

3.—An increase of the estimate for aeroplanes and equipment to be supplied by the militia division of the War Department to the National Guard from less than $1,000,000 to $2,000,000

4.—A sum of $2,000,000 for providing dirigible and kite balloons for the Army

5—A sum of $1,000,000 for the organization of a civilian aviators' reserve corps

6—A sum of $3,000,000 for providing dirigible and kite balloons for service with the Navy

7—A sum of $1,000,000 for establishing a chain of aerial coast patrol stations, to be operated either by the Navy or by the Naval Militia, in cooperation with the Coast Guard or separately

The figures given below, based on the experience of the United States Army Aero Corps, give the estimated cost of equipment for one Army aero squadron of twelve machines (base number) in the field, always ready for service on the first line

30 aeroplanes, complete with instruments, etc (1½ spare for each one on line at start of year) at $13,500 each, an estimate of average cost of high powered service military machines of latest types	$405,000.00
20 spare motors (some machines will be twin motored) at $5,000 each average	100,000.00
Spare aeroplane parts one year for the 30 aeroplanes	80,000.00
Spare motor parts one year	55,000.00
Gasoline	30,000.00
Oil	6,000.00
Tent hangars and repairs	8,000.00
2 motorcycles	550.00
20 trucks	53,000.00
2 automobiles Fords	1,000.00
Gasoline oil and grease for trucks, etc	8,000.00
Field machine shop, tools machinery stock and material	7,000.00
Miscellaneous	20,000.00
	$773,550.00

This estimate does not include cost of any land, cost of any permanent shops, hangars or other buildings, or pay of any officers, civilian expert mechanics or enlisted men, or of any material used in training pilots.

The Harvard Flying Club

Several Harvard alumni, led by Robert Bacon, formerly Ambassador to France, have established a fund for the training of Harvard students in aviation.

The committee has received many applications from Harvard undergraduates who want to learn to fly, some of them among the best athletes in the University The first nine selected were Frederick S Allen of Pelham Manor, Francis T. Armory, Jr., of Boston, Edmond H. Bates of West Medford, Mass, William B Bacon, M. Philip Bryan, and Hamilton Coolidge of Brookline, Mass., Donald D Harries of Minneapolis, Harry H. Metcalf of Westboro, Mass., and Joseph R Torry of Worcester, Mass.

These men have reported to the Curtiss Aviation School in Buffalo and are now in training Mr Bacon and the Aero Club of America have offered a bonus of $50 for each student obtaining his license The fund now amounts to $4,681, with $2,400 pledged for the future.

The Executive Committee in charge of the collection and distribution of the fund are: William Thomas, George von L. Meyer, G. Richmond Fearing, N. Penrose Hallowell, Allan Forbes, Eliot Wadsworth, Philip A Carroll, S Huntington Wolcott, E V R Thayer, Charles E Perkins, Benjamin Joy, A J Drexel Paul, Roger Armory and Gordon H Balch

It will cost about $400 to train each man so that he may be able to take the tests for his pilot's license, and $10,000 more is needed to carry the plan to completion The committee invites subscriptions from Harvard men and those interested in the welfare of the nation, which should be sent to the Undergraduates Aero Training Fund, 40 Water Street, Boston, Mass

The New York Flying Yacht Club

The New York Flying Yacht Club has secured permission from the Department of Parks and Docks of New York to establish a hydroaeroplane station at 129th Street on the Hudson River This club was recently organized by J. C. Mars and Augustus Post to provide facilities for owners of air craft in New York City An aviation field will also be procured as soon as possible The club is modeled on the plan of the yacht clubs that have been so successful in various ports of the country, and is the first of a type that is sure to become very popular One of the first events planned is the "Manhattan Island Derby," for which a trophy valued at $5,000 and cash prizes of $5,000 will be offered.

There are now twelve sportsmen aviators who live within flying distance of New York, and these are interested in the North River station, as it will make it possible for them to fly to the city each day They will land at the station and leave their machines in the hands of competent mechanics, who will have them tuned up and ready for the flight home after their owners have finished their day's work Three aeroplane manufacturers have made application for hangars at the station where they can keep machines for demonstration purposes

The Aero Club of Illinois

A new aerial volunteer force has been organized in Chicago by the Aero Club of Illinois under the name of U. S. Central Aviation Reserve Plans for the organization of this force are completed, there will be a full squadron composed of three companies, with a total of 140 officers and men Two high-powered tractor biplanes have already been ordered for the First company, and all but a few hundred dollars of the $20,000 necessary to make the purchase have been subscribed.

More than 150 men, some of whom have seen military service, enlisted for service with the squadron

The Aero Club of Vermont

The Aero Club of Vermont was organized at Fort Ethan Allan, Burlington, Vt., on July 6. The president of the club is James Hartness of Springfield, Vt., who is an old-time enthusiast of aviation Many of the members belong to the Norwich Military College.

The formation ceremony was held on the parade ground of the state encampment, where the visitors were welcomed by Governor Gates. The Aero Club of America was represented by Rear Admiral Peary and Augustus Post.

Liberal Naval Aeronautical Appropriations Are Expected

WASHINGTON, July 31.—No changes of importance are anticipated in the Naval Appropriation bill as far as aeronautical matters are concerned as a result of the coming conference of the House and Senate committees, according to those who have been following the legislative activities. The features of this bill are of special interest, as besides making more liberal appropriations than have ever before been made in this country, it creates a Naval Flying Corps, a Naval Reserve Flying Corps and an Aerial Coast Guard Service. The proposed appropriations, which amount to $5,762,000, will prove a decided spur to increased aeronautical improvement and advance. A brief summary of the legislation under consideration follows:

The Proposed Appropriation

For the procuring, producing, constructing, operating, etc., of aircraft of different kinds, including dirigibles, and the maintenance of aircraft stations and the conducting of experimental work in the development of the aeronautical science for naval work, the sum of $3,500,000 is provided. In addition to this, $85,000 is appropriated for the Naval Advisory Committee of Aeronautics to cover the expense of office, field shop, shed, power plant, instruments, supplies, expenses and employees.

For the purchase of 232 acres of land near San Diego Bay, Cal., to be used as an advance base and for expeditionary and aviation purposes, $250,000 is made available, provided that a certain plot of 500 acres is donated to the service. The sum of $420,000 is set aside for repairing the storm damage done at the Pensacola aeronautical station and $1,500,000 is made available for the Naval Advisory Board's experimental and research laboratory at Washington.

The Coast Guard is to receive $7,000, and by another bill which has been introduced into both house of Congress an Aerial Coast Patrol of the Naval Militia is to be established, $1,500,000 being appropriated for the purpose.

The Naval Flying Corps

By the terms of the proposed legislation the Naval Flying Corps is to be composed of 150 officers and 350 enlisted men, in addition to the total number provided for other branches of the naval service. One of the interesting features is the provision that civilians may join the Naval Flying Corps. For two years after the passage of this act the Secretary of the Navy may appoint, in order of merit as determined by examinations, fifteen acting ensigns or acting second lieutenants for the performance of aeronautic duties only. These appointments may be made from officers, enlisted men or from civil life, and shall be detailed in the Naval Flying Corps for duty involving actual flying.

Opportunity for Advancement

Such acting ensigns of the Navy and acting second lieutenants of the Marine Corps, upon the completion of the probationary term of three years, may be appointed acting lieutenants, junior grade, in the Navy or acting first lieutenants in the Marine Corps for the performance of aeronautic duties only. These appointments are for a probationary period of four years. The appointees may elect to qualify for aeronautic duties only, or for all duties of officers of the same grades in the Navy and Marine Corps respectively. Those who qualify for aeronautic duty only shall be detailed to duty in the N. F. C. involving actual flying. Those who qualify for regular duties shall be detailed to duty in the regular service for at least two years to allow them to prepare for such qualifications.

Acting lieutenants, junior grade, and acting first lieutenants who have been chosen to qualify for aeronautic duty only, on completion of the probationary period of four years, shall be commissioned in the grade of lieutenant in the line in the Navy or as captain of the Marine Corps for aeronautic duty only after examinations. They are to be carried on the list as extra numbers, taking rank with and next after officers of the same date of commission. A similar course is provided for those who qualify for the regular duties of the line.

It is farther provided that acting lieutenants, junior grade, of the line of the Navy, and acting first lieutenants of the Marine Corps, who have completed the probationary period of four years, may be transferred to the Naval Reserve Flying Corps. Officers commissioned for aeronautic duty only are eligible for advancement, but not above the grade of captain in the Navy or colonel in the Marine Corps.

Civilians May Be Appointed

The Secretary of the Navy is authorized to appoint annually for a period of four years from enlisted men in the naval service or from citizens in civil life not to exceed 30 student fliers for instruction and training in aeronautics, who shall receive the same pay and allowances as midshipmen at the Naval Academy. Student fliers must qualify by examinations prescribed by the Secretary of the Navy. The appointment of naval fliers shall continue during a period of two years, and at the end of that period they shall, on examination, be transferred to the Naval Reserve Flying Corps and commissioned as ensigns therein. When actually flying they shall receive pay and allowances as midshipman plus fifty per cent. The Secretary of the Navy is authorized to establish schools for the instruction and training of student fliers.

The Naval Reserve Flying Corps

The Naval Reserve Flying Corps will be composed of officers, enlisted men and student fliers, transferred from the Naval Flying Corps. Graduates of the aeronautic school who are not required in the regular service may be commissioned ensigns in the Naval Reserve Flying Corps, and members of the Naval Reserve Force who are skilled in flying, designing or building are eligible for membership in the Naval Reserve Flying Corps.

The Coast Guard Service

The proposed legislation also authorizes the Secretary of the Treasury to establish and maintain not over ten aviation stations on the Atlantic, Pacific, Gulf and Great Lakes coasts and to detail for aviation duty officers and enlisted men of the U. S. Coast Guard Service. Instructors may be employed at the salaries of $4,000 and $3,000.

At the request of the Secretary of the Treasury, the Secretaries of War and the Navy are authorized to receive officers and men of the Coast Guard Service for instruction at any aviation school maintained by the Army or Navy. Increased pay is also allowed to those engaged in aviation duty. Not more than a yearly average of 15 officers and 40 men of the Coast Guard detailed for aviation duty involving actual flying are permitted to receive increase of pay.

The Research Laboratory

The experimental and research laboratory of the civilian Naval Consulting Board, for which the bill appropriates $1,500,000, is to be located in Washington and its cost limit has been put at $2,000,000. The research work is to include aircraft with ordnance, submarine protection and many things that will interest the aeronautical engineer.

The Naval and Military Aero Services

The Army Orders Forty Machines

The forty aeroplanes for which the War Department recently placed orders will be furnished by seven aeroplane concerns, as follows:

Twelve Curtiss model R-2 tractor biplanes with 160 h.p. engines and six Curtiss twin-tractor biplanes with two 90 h.p. engines each;

Twelve "Standard" biplanes with 125 h.p. Hall-Scott tractor-biplanes;

Two Martin, model S, convertible tractor biplanes with 125 h.p. Hall Scott engines;

Two Thomas tractor biplanes with 135 h.p. Thomas engines;

Two L. W. F. tractor biplanes with 135 h.p. Thomas engines;

Two Sturtevant steel tractor biplanes with 135 h.p. Sturtevant engines; and

Two Wright biplanes with 140 h.p. Hispano-Suiza Simplex engines.

Each concern will also furnish one spare engine with every machine.

Army Aeronautical Reserve is Established

Acting upon recommendation by the War Department, President Wilson signed on July 13 an order establishing an Aeronautical Reserve for the U. S. Army, which is to provide one aeroplane squadron for each of the twelve divisions of the organized militia. Each squadron will be composed of three companies and each company will have four machines.

The President's order, which is based on the National Defence Act of June 3rd, 1916, will bring 297 officers and about 2,000 enlisted men of the organized militia to the aeronautical reserve, enlistments will begin without further delay for the purpose of bringing up the reserve to full strength.

Any American citizen with experience in aeronautics or general mechanical ability may join the reserve and should make his application to the adjutant-general of his state. To facilitate the work of organizing the reserve, the War Department will cooperate with the Aero Club of America, its affiliated clubs and other societies, aviation schools throughout the country will also be encouraged with a view of providing speedy and efficient training for officers and men.

The War Department will accept graduates of private aviation schools for service after they pass the prescribed examination, in which case the cost of tuition will be refunded to them.

French Sea Plane Tested for the American Navy

A new naval seaplane of French construction is being tested at Juvisy, France, for the U. S. Navy, under the supervision of the U. S. Naval attaché to France. The machine is a Paul Schmitt biplane with catamaran floats designed by M. Tellier, the French expert; it has a 150 h.p. Salmson engine, driving a tractor screw, and nominally controlled (variable) incidence.

Eight Aeroplanes for the California National Guard

Members of the Pacific Aero Club are eager to enlist as a state squadron to go to the border with the National Guard of California. They have offered to place eight aeroplanes and three observation balloons, with pilots, at the disposition of the California guard officers. J. C. Irvine, president, and Guy T. Slaughter, vice president, of the Pacific Aero Club, are the leaders of this movement.

National Kite Balloon Presented to the Ohio Guard

The National Guard of Ohio is the first volunteer force to possess a kite-balloon for directing artillery fire. The craft was presented to Battery B, Ohio Field Artillery, which is stationed at Akron, O., by the Goodyear Tire and Rubber Co., and is of the same type as the one recently delivered to the Naval Aeronautical Station at Pensacola, Fla.

Massachusetts is Forming an Aviation Company

The National Guard of Massachusetts is recruiting an aviation company for its signal corps. Several aviators have already offered their services as instructors for the new company, and one of the officers will probably be Capt. Harry Metcalf of the Harvard Flying Corps.

Mrs. Vincent Astor Christens Sea Plane

The second seaplane of the New York Naval Militia, which was presented by a Citizens' Committee headed by Vincent Astor, was christened "No. 1" on July 11 by Mrs. Vincent

(c) International Film Service

Astor at Brooklyn. The seaplane was assigned to the Second Battalion, N. Y. N. M., where it will be in charge of Ensign Pierce. The machine is a Burgess-Dunne biplane.

The Aerial Coast Patrol is Forming

The Aerial Coast Patrol, which is being developed under the auspices of the Aero Club of America by the National Aerial Coast Patrol Commission, of which Rear Admiral R. E. Peary is chairman, is about to establish its first unit.

F. T. Davison, son of H. P. Davison of J. P. Morgan and Company, and Robert Lovett, son of R. S. Lovett of the Union Pacific Co., have placed an order for a 90 h.p. Curtiss flying boat, which will be the first machine of the Aerial Coast Patrol. The two gentlemen have also joined the aviation school at Port Washington, L. I., to begin their training as aviators. Three Yale Men, Alan Ames, H. D. Sturtevant and C. D. Wynan, are training at the same school for service with the Aerial Coast Patrol.

It is planned to form a unit of twelve men, all trained aviators, four of whom will act as pilots, four as observers and four as anti-aircraft gunners. Two experts in wireless telegraphy will be added, one to direct a local radio station and the other to install and operate the wireless set on the seaplanes. The full equipment of the unit will consist of four seaplanes, with a number of automobiles and motor boats as auxiliaries.

New Students at the Army Aviation School

Three more students have joined the Army aviation school at San Diego, Cal.; they are Joe H. Hopwood of Fresno, Cal., Reuel Martin of Chowchilla, Cal., and Jas. A. Martin of Sanger, Cal.

The Chambers Catapult is Giving Satisfaction

The seaplane launching service known as the Chambers catapult, which has given entire satisfaction on the U. S. S. *North Carolina*, is shortly to be installed on the U. S. S. *West Virginia* and *Washington*.

THE STURTEVANT 140 HORSE-POWER STEEL TRACTOR

A Number of Machines of This Type Are Now Being Constructed for the United States Government

IT IS REPORTED THAT—

PHIL RADER, the American aviator who held a lieutenant's commission with the Royal Flying Corps, is now one of the instructors of the Curtiss Aviation School at Buffalo, where he is responsible for the tuition of eight Harvard students.

O. E WILLIAMS and ALFRED BOSHEK of the Fenton Aviation School of Fenton, Mich, celebrated Independence Day at Boise City, Idaho, with exhibition flights.

ALFRED NOREMBURG, of the same school, is on an exhibition tour through the northern part of Michigan.

JOHN DOMENJOZ, the Franco Swiss looper, is demonstrating acrobatic flying in the Northwest.

MAX A. HERBERT, Montclair, N J, has designed a rigid airship propelled by four electric motors, which he offers for sale to the government.

WILLIAM EARL DODGE, brother-in-law of John McCullough, will take up aero yachting at Newport this season.

CAPTAIN HUGH L. WILLOUGHBY, the veteran aviator, intends to put a new aeroplane of his own design through its paces at Newport, R. I.

CAPTAIN THOMAS S. BALDWIN has been elected a charter member of the newly organized Aero-Nautical Club of Virginia, with headquarters at Newport News, Va.

LEON CANADY, of Newton, Kan., is unable to volunteer his services to the government in conjunction with the planned civilian aviators' training camp, as he has several exhibition contracts to fulfill during the summer.

ROBERT WHITE, of Seneca Falls, N. Y., a certified aviator, has joined the New York National Guard.

N B. ROBBINS, of Des Moines, Ia., and E O WEEKS, of Eagle Grove, Ia., have offered their services to Adjutant-General Guy Logan, commanding the National Guard of Iowa.

C V. CESNA, the Hutchinson (Kan.) aviator, was seriously injured by a bad landing caused by engine trouble.

H PAYNE WHITNEY, Yale '98, is organizing from among Yale 'varsity oarsmen, past and present, an aviation corps, which he will equip.

THOMAS PRESTON BROOKE, of Chicago, has completed the construction of a novel seaplane, which he intends to try out on the Lake Front at Chicago.

NICHOLAS R MAURER, an exhibition aviator of Hastings, Minn., has enlisted in the Aviation Section, U. S. Signal Corps. He has been assigned to the Army Aviation School at San Diego, Cal.

FRANK BRYANT, the Christofferson pilot, gave a number of exhibition flights to the people of Maricopa, Cal., on July 4th.

A. C. BEACH entertained the members of the Society of the 28th Regiment, Wisconsin Volunteer Infantry, during their annual meeting at Waukesha, with an exhibition of spirals and nose-dives.

TRADE NOTES

The CHAMBER OF COMMERCE of Redwood City has raised $18,000 for the purpose of having Silas Christofferson, the San Francisco constructor, erect a permanent aeroplane factory in that city.

The POLSON IRON WORKS LTD., of Toronto, Canada, is about to put a new high speed tractor through its preliminary tests.

The EXCELSIOR PROPELLER CO. of Saint Louis, Mo., has shipped under rush orders from the government three aeroplane propellers to the army base at Columbus, N. M., where several army aeroplanes are laid up with broken propellers.

The Chinese Government has place an order with the CHRISTOFFERSON AIRCRAFT CO of San Francisco for the prompt shipment of 25 tractor biplanes.

The AMERICAN AIRCRAFT COMPANY, of New York and Washington, D. C., have acquired the patent rights of the Duprée all-metal "aeromobile." Frank Duprée, inventor of the machine, hopes to attain a speed of 100 miles per hour with the "aeromobile," which will be fitted with 300 h.p. engines.

R. H Upson, of the GOODYEAR TIRE & RUBBER CO., is with the Ohio Field Artillery, and R. A. D Preston, of the same company, who is studying in Europe, will return home Sept. 1st.

The following officers of the AMERICAN AIRCRAFT COMPANY, 120 Broadway, New York, have been elected: Frank Dupree, president; Howard Huntington, vice-president; Douglas Huntington, secretary and treasurer.

Thomas Aeromotor Passes Government Test

Naval Inspector Charles Creswell, stationed at Ithaca, N. Y., in speaking of the test of the first of a quantity of 135 horse power motors being manufactured by the Thomas Bros. Aeroplane Co. for the United States Navy, is quoted as saying: "The Thomas motor successfully passed its continuous eight hour full load run. The motor ran 2050 revolutions throughout the test and was noticeably free from vibration."

The horse-power developed was 141 at the propeller shaft turning 1230 revolutions per minute. The gasoline consumption figured out at 12.5 gallons per hour and the oil consumption at 1.6 gallons per hour. The motor was remarkably free from oil leakage during the run and called forth much favorable comment at the end of the test.

It will be remembered that the Thomas aeromotor was one of the first aeroplane motors to fit a self-starter as regular equipment. This instrument, a Christenson combination air and gasoline starter, selected by the Thomas engineers after the most exhaustive trials, demonstrated its value by the ease with which the motor was started on this test. Throughout the run the two Dixie "80" magnetos performed with marked regularity, all spark plugs firing without a miss.